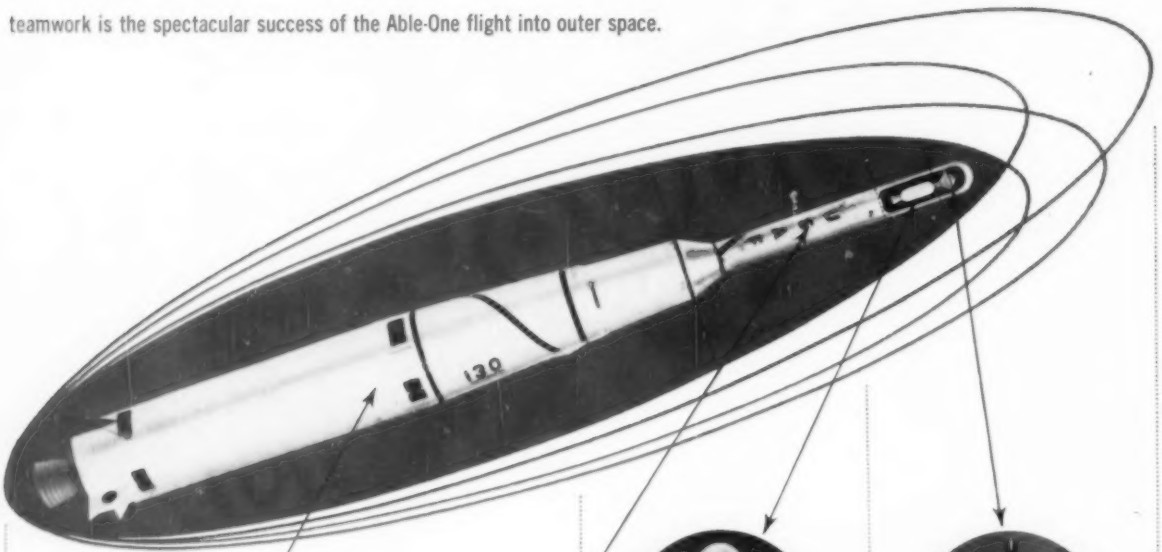
industrial RESEARCH

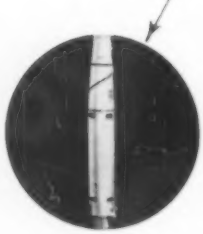
75 cents january 1959

HE MANAGEMENT MAGAZINE OF TECHNICAL PROGRESS

Able-One... a new apogee in scientific teamwork!

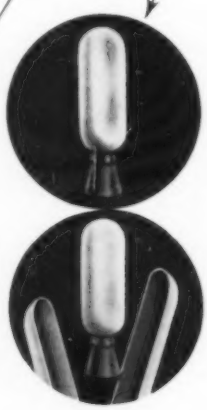
Preparation and execution of an undertaking such as the United States' IGY space probe demanded the participation and exceptional efforts of 52 scientific and industrial firms and the Armed Forces. The Advanced Research Projects Agency and the AFBMD assigned Space Technology Laboratories the responsibility for the project which was carried out under the overall direction of the National Aeronautics and Space Agency. One measure of this teamwork is the spectacular success of the Able-One flight into outer space.





1st stage: Vehicle, Douglas Aircraft **Thor** IRBM; propulsion, Rocketdyne; airframe, control, electrical and instrumentation, Douglas Aircraft; assembly, integration, and checkout, Douglas Aircraft.

2nd stage: Propulsion system and tanks, Aerojet-General; control, electrical, instrumentation, accelerometer shutoff, and spin rocket systems, STL; assembly integration, and checkout, STL.



3rd stage: Rocket motor, U. S. Navy Bureau of Ordnance and Allegheny Ballistic Laboratory; structure and electrical, STL; assembly, integration, and checkout, STL; ground testing, USAF's Arnold Engineering Development Center.

Payload: Design and production of **Pioneer,** the payload of the Able-One vehicle, was conducted by STL in addition to its overall technical direction and systems engineering responsibility of the Air Force Ballistic Missile Division project. This highly sophisticated package included a NOTS TV camera and transmitter and Thiokol rocket motor.

Inquiries concerning openings on our staff will be welcomed by

Space Technology Laboratories, Inc.
5730 Arbor Vitae Street, Los Angeles 45, California.

january, 1959 **RESEARCH**

THE COVER: White heat glares as open hearth furnace at U. S. Steel's Gary Steel Works is tapped. Slag overflows (left) into thimble. Gary Works is biggest raw steel producer in the world, but is it, with the rest of U. S. steel industry, the best? (See article beginning on page 19 of this issue.)

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is there really a shortage of engineers?

world-wide television and telephone dialing

the world's hottest alloys

machines that perceive

reinforcing the plastics revolution

organizational decision-making research

. . . and other articles of interest to industrial executives

research comment

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editor — Neil P. Ruzic
advertising director — Henry G. Swambat
circulation manager — M. P. Bertness
photographer — Jon R. Pownall
technical editor — Dr. H. L. Garbarino
news editor — Walter Esse
contributing editors — K. M. Wylie Jr.; Dr. Joseph W. Still; D. H. Radler

advertising representatives

New England — A. Jay Davis, Litchfield, Conn., JOrdan 7-9191
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IR RESEARCH COMMENT

RESEARCH COMMENT is an editorial: a column of pros, cons, interpretations, plans, criticisms—in short, IDEAS. *Some are good ideas, some bad, but even the latter are worthwhile since mistakes can be profited by.*

Wages, morals, research

Business today is criticized for taking a weak stand against inflation—which means failing to fight unions and their wage increases more vigorously. It wasn't too many years ago that the suggested attitude would have been hailed as big-business hunger, called Greed.

Something new has been added to the firepot in recent years which makes a middle road both moral and anti-inflationary. It's industrial research, probably the fastest growing major "industry" in America. By creating new products and better ways of doing things, industrial research is our main hedge against inflation in a defense-spending economy.

Latest productivity figures, incidentally, support this view: today's workers turn out 37% more than a lesser number did in 1948.

Individual vs. team

Promoters of institutional research are ill-informed about facts according to W. J. Kroll, originator of the famous Kroll process used for producing metallic titanium and zirconium.

Kroll points out that in the last few years two-fifths of all U. S. patents have been taken out by individual inventors, and that only a very few institutional scientists ever received the Nobel Prize. To support his view he cites the book, *The Sources of Invention*, which lists 33 twentieth-century individual inventors who brought about great advances and only 21 famous "team" inventors.

The problem seems to break down into basic and applied research. The former needs little organization and not much equipment—only an idea.

But applied research does lend itself to organization, and one way of increasing technological development is by increasing technological development activity. Setting up institutions and teams just happens to be the easiest way of accomplishing this.

Is videotape in your future?

Recent "newsletters" have given the impression that industry can save all kinds of money with the new videotape. They point to the fact that tape, which needs no processing, is 90% cheaper than film and that it can be erased and used again.

That's true, and we're all for it. But let's be reasonable. Videotape machines *today* cost $50,000 and weigh 1,000 pounds. The TV people are almost the only ones who can afford it currently. They record live shows on tape for rebroadcasting—so much so they've increased tape recorders for this use by 1,000% during the past year.

Later, though, if research can bring down the price (the heck with the weight) you'd simply point a TV camera instead of a movie camera. The image signals from the camera would go to a tape recorder, thence to one or more closed-circuit telescreens—in one or more places.

Future applications will include motion studies, disassembly of machines, executive speeches, conferences, conventions, etc.

For the straight story on industrial applications of videotape and other magnetic recording uses and current research, see the joint articles beginning on page 58 of this issue.

A fourth service?

A lot has been said about centralizing military R&D as a separate civilian activity. Clifford R. Rassweiller, president of the American Chemical Society, has a better idea.

He wants us to have a fourth branch of the military outside the Army, Navy, and Air Force for this purpose. Such a service would provide incentives for officers to devote their careers to R&D—which is not possible under the present system.

John L. Burns, president of RCA, goes one step further. Burns says the need for overall planning in all fields of interest to the nation is so urgent that a fourth branch of government is necessary. Ranking in importance with the legislative, executive, and judicial branches, the "Permanent Council on Plans and Policies" would be made up of top leaders in education, science, business, etc. Its function: to look to the future.

Weapons development

The Army's R&D chief, Lt. Gen. Arthur G. Trudeau, says the services could speed weapons development if industry were allowed more flexibility.

His comment: "Many times I've authorized companies to change details of a project and then watched 150 other civilians and lieutenant colonels check on it."

We don't hear industry disagreeing.

Have rocket—let's travel

Dr. H. S. Seifert of the Space Technology Labs in Los Angeles comments that at least 10 companies "have rocket—will travel." He believes that propulsion is no longer the limiting factor in space travel—that guidance and communication now are the real problems.

comment . . .

Anti-smog

A radical change in the nation's attitude toward air pollution is taking place. The change is reflected by city air pollution control budgets. Los Angeles County spends almost $4 million a year; New York City about $670,000. Expenditures by industry for control measures are staggering. A large steel company recently reported spending $12 million to anti-smog just one plant.

Anti-water pollution

The U. S. Public Health Service promises an all-out federal-state war on industrial water pollution. The battle includes expenditures for researching conversion of wastes to harmless or useful materials, and court crackdowns on companies that pollute interstate streams.

Anti-smoking

Several cases of damage suits have been brought against cigaret companies by the widows of smokers who have died of lung cancer. While none of these cases has been decided yet, they may develop into court tests of the strong evidence that smoking can cause cancer.

The public isn't worried though. A record 457 billion cigarets were produced in 1958. That's about 15½ billion more than 1957, the previous high, or 180 packs per adult per year.

Atomic competition

The government should stop pushing small firms into the atomic energy business, according to big-firm official, Dr. Chauncey Starr, of North American Aviation.

Starr isn't trying to cut out competition. It's just that he feels the government's spread-the-work philosophy is "encouraging economic catastrophe" for many smalls.

He points to a historical trend in which only a few companies have survived in any industrial endeavor calling for vast facilities and huge work forces. Only three firms now make steam turbines, he says, and the atomic business calls for more resources than turbine making.

Atomic liability

The new atomic energy industry is seriously hampered by the prevalent principle of absolute liability. Under a system where companies are held liable for all damages, even though accidents occur through no fault of their own, they may find it impossible to insure themselves fully.

On this question, Dean E. Blythe Stason, of the University of Michigan Law School, suggests that where legislation provides for absolute liability, it should also fix maximum rates of payment for damages. Laws to this effect now are under consideration in Britain and West Germany.

Population exploding

The world population is galloping upward at the speed of 100,000 births per *day*.

If this continues to the end of the century, Latin America will have almost twice as many people as the U. S. and Canada combined—or 593 million. Asia, though, is exploding at the rate of 4 million a year, and will have almost 4 *billion* people by that time.

What this means in human misery and crowding is hard to imagine. In Saudi Arabia, for instance, the population density is already more than 3,000 persons per square mile (as against 239 Americans per square mile).

Consider for a moment the job of feeding and educating these hordes today and the billions more in the comparatively near future. Then consider it again in a research sense.

This is what prompted formation of a new group in England called the Council for the Investigation of Fertility Control. The CIFC is carrying out tests for a pill that can be swallowed and prevent pregnancy. Amid the usual church and other objections, the council is testing a promising U. S.-developed pill on 1,000 volunteer British wives.

Like most other specific developments, a workable birth control pill is only a small part of the complex. History shows that population decreases as industrialization increases. Thus, industrial development generally, and its successful exportation, becomes the best birth control "pill."

Heredity control

A revolutionary heredity theory — that controlled irradiation and chemical treatment of reproductive organs can produce desired changes in plants and animals—has been proposed by Dr. O. G. Fahmy, of the Institute of Cancer Research in London.

Fahmy geneticists (still in the minority) hold that mutations can be controlled by a skilled person. If they're right, meat will be tenderer, fruit seedless, vegetables weather-resistant, and man . . .

Mother love

Continuous mothering is not only unnecessary but probably harmful, according to many psychologists, including one who did some current research on the subject, Dr. Albert I. Rabin, head of Michigan State's psychological clinic.

Rabin's studies of the Kibbutzim, or collective settlements, in Israel indicate that Kibbutz children developed positive attitudes toward their parents despite limited contact.

Physical contact, however, is a much more important influence on an infant's love for its mother than is the food she gives—according to another experiment using monkeys. Dr. Harry F. Harlow, of the University of Wisconsin, built two mother substitutes for his monkeys. One used sponge rubber covered with terrycloth; the other was made of wire screen. Both were warmed by radiant heat.

Even when the wire mother gave the baby milk while the cuddly mother did not, the baby monkey preferred the terrycloth mother.

From this it could be deduced that the human father is physically endowed with all the really essential equipment to compete with his wife in the rearing of infants, custody court decisions notwithstanding.

Symptom strips

A medical slide rule recently developed has about 80 strips stored in its back. Each strip has a different symptom of illness. Some 340 disease categories are listed on one side of the rule's front. From one to six symptom strips then can be inserted under a window for matching and reading.

All this naturally prompts the question of what the doctor's for. Or are we now to have symptom strip specialists?

Our cyclotron is bigger . . .

Publicity stories have appeared about the University of California doubling the energy of its 184-inch cyclotron so that protons of 730 million electron volts can be fired. The machine now becomes the world's most powerful cyclotron, say the stories, exceeding by a few Mev a similar machine in Russia.

Our reaction to this comparison (not

continued on page 29

What's in a name?

"Volume one, number one" of a magazine is mostly a state of mind, a very minor accomplishment compared to the many better issues locked into the future. Yet, number one is the most important issue of a magazine's life because it announces Purpose and Goal. In I•R's case, Purpose is tightly mixed into Name. Conceived as "Scientific Research," the purpose of the magazine became better defined in time for birth.

Thus to answer your question:
What happened to that magazine
I read about to be called "Scientific Research?"
Well, here it is.

Called "Industrial Research," its single purpose is to help management men keep informed of their newest responsibility: the profitable application of industrial research.

Its goal: to help place research on a par with other management functions such as sales, finance, production, and engineering, and—by doing this—to help reduce the time lag between invention and production.

In forthcoming issues of Industrial Research, you will read about significant new developments, controversies, ideas—and how they relate to your business—in the fields listed to the right.

Acoustics
Air Pollution
Aeronautics
Atomic Energy
Automation
Automotives
Biochemistry
Building Materials
Cartography
Ceramics
Chemicals
Coatings
Communications
Containers
Components
Computers
Crystals
Cryogenics
Electronics
Explosives
Finance
Food Technology
Fuels
Glass
Heat Transfer
Hydraulics
Industrial Design
Industrial Engineering
Industrial Medicine
Instrumentation
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Magnetics
Management
Marine Design
Mechanics
Metallurgy
Mining and Minerals
Missiles
Natural Resources
Nucleonics
Optics
Ordnance
Paint and Pigments
Paper
Petroleum
Photoengraving
Photography
Physics
Plastics
Power
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Product Engineering
Propellants
Process Engineering
Pyrogenics
Radar
Radio
Railroads
Rare Earths
Reactor Technology
Rockets
Rubber
Safety Engineering
Sanitation
Semiconductors
Space Travel
Standards
Structures
Synthetics
Telegraphy
Telephony
Textiles
Transportation
Water
Weapons
Weather Engineering
Wood Technology

'ETCH PITS' *in a new silicon steel illustrate cube-orientation as seen through a microscope. This steel can be magnetized easily in four directions instead of two. This is the first major silicon-steel improvement in many years, and is expected to bring smaller electrical equipment in 1959.*

STREAKING ACROSS THE SKY, *this missile is one of hundreds that will be fired during 1959—at a total cost in excess of $2,000,000,000.*

1959 Forecast: $12 BILLION

Expenditures for research and development in the United States totalled almost $11 billion in 1958, and are estimated to amount to $12 billion in 1959.

By contributing so significantly to gross national product, research has become an industry in itself. It's a unique new industry because it both creates and increases demand for new products and also stabilizes the economy by introducing technology that must be financed by long-range plans.

Half the money for research today is provided by the federal government, but most of the government's research money is spent by industry.

The latest National Science Foundation survey showed that in 1956, American industry spent $3.3 billion of its own funds and $3.1 billion of government funds for R & D. If the research dollar is divided in 1959 as it was in 1956, the $12 billion for R & D this year will be spent like this:

- Industrial R & D financed by industry ..... $4.5 billion
- Industrial R & D financed by government 4.2
- Government R & D in its own laboratories 1.9
- Universities and institutions 1.4

The recent recession proved no deterrent to research spending by most companies. A survey by the American Management Association showed that industrial R & D budgets for 1958 averaged 4% higher than in 1957.

Budgets were down 15% in the construction machinery and 6% in the auto industry. But they were higher in most other industries—8% higher in foods and 10% higher in chemicals, for example.

The greatest effect of the recession probably was to restrict spending to the development end of the R & D scale, at the expense of longer-range research. As the AMA put it, emphasis was on development of items "close to the shipping-room door."

Here's how various types of industries probably will spend their 8.7 billion R & D dollars in 1959:

- Aircraft and parts ..... $2,840 million
- Electrical equipment 1,600

Research accomplishments to expect in 1959:

- Earth satellites with TV cameras.
- Rockets to the moon.
- Flat, 'picture-frame' TV sets.
- New "mood drugs" to control personality.
- New drugs with limited anticancer action.
- Electroluminescent light panels.

What not to expect in 1959:

- Manned rockets to the moon.
- 'Space platform' satellites.
- Plastics for ultra-high-temperature service.
- Drugs that will cure cancer.
- Practical atomic fusion.

by Dr. Charles E. Feazel, head, applied chemistry division, Southern Research Institute

FOR RESEARCH

■ Machinery	830
■ Chemicals and allied products	670
■ Professional and scientific instruments	370
■ Petroleum products and extraction	340
■ Fabricated metal products and ordnance	240
■ Telecommunications and broadcasting	230
■ Primary metals	120
■ Rubber products	110
■ Food and kindred products	100
■ Stone, clay, and glass products	90
■ Paper and allied products	60
■ All other industries	1,300

Among individual "big spenders" for research last year were General Electric, which spent more than $250 million for research in 1958; Westinghouse Electric, $150 million; Union Carbide, about $65 million; Du Pont, more than $50 million; International Harvester, about $37 million; and International Business Machines, more than $24 million.

Flight into air and space

The lion's share of the almost $3 billion worth of air research in 1959 will be government-supported, with $2 billion alone earmarked for military R & D on missiles. This money will support work on intercontinental and intermediate range ballistic missiles, as well as a host of smaller defense and tactical missiles.

Having successfully fired several Convair Atlas ICBM's, the Air Force is moving into development of a second ICBM, the Martin Titan. The Navy's Lockheed IRBM Polaris will undergo further test firing during 1959.

This year will see the first manned "space flight" in North American Aviation's X-15, a ballistic-glide research missile that will make hypersonic flights above 100 miles altitude.

Part of the research conducted with the X-15 will be the responsibility of the new National Aeronautics and Space Administration, which took over the functions of the National Advisory Committee for Aeronautics. During this year, NASA plans to spend more than $150 million on R & D, in its own facilities and under industrial contract. The Vanguard satellite program became the responsibility of NASA. Future space projects will be divided between NASA and the defense agencies.

This year also will see several more rocket probes at the moon, planned either to hit the moon or to orbit it. Launchings are planned by both Army and Air Force, under auspices of the Advanced Research Projects Agency. The rockets will carry cosmic-ray instrumentation and TV cameras for scanning the moon's surface.

TV satellites

Some of the earth satellites to be placed in orbit during 1959 are to carry TV cameras. Rocket engines with the million-pound thrust needed to launch satellites weighing one ton or more are being developed.

Nuclear-powered aircraft will receive relatively less attention. GE is continuing its program at Evendale and Idaho Falls, but government expenditures for the program in fiscal 1959 ($145 million) will be somewhat less than originally planned. Current emphasis appears to be on getting some type of atomic plane into the air, whether it represents optimum design or not.

The stepped-up missile program has intensified the search for improved materials and components—fuels with high energy content, electronic equipment that will function at red heat, and metals for use at high temperatures.

The re-entry problem—how to design a missile that won't burn up by friction when it re-enters the atmosphere after a trip through space—is regarded by many experts as nearly solved, through the use of specially designed nose cones and missile skins.

Several approaches are being explored. One is to use refractory metals or ceramics that won't melt or weaken at the temperatures involved. Another is to make the nose cone of a plastic that will be ablated, or sloughed away, a calculated amount by air friction during the missile's downward flight.

Metals: hotter and purer

A significant part of research in the metal industries will continue to go toward developing materials that can retain strength at the extremely high temperatures encountered in missiles, jet engines, and gas turbines. Efforts will be made to extend the performance range of nickel and cobalt alloys above the present limit of 1800°F, by adding small amounts of elements like columbium or tungsten.

Climax Molybdenum and Westinghouse, among others, are active in research on high-melting alloys of the refractory metals tungsten, tantalum, columbium, and molybdenum. Alloys of these metals retain their strength at temperatures above 2000°F. But they are oxidized easily in air at high temperatures.

More refractory ceramic coatings will be developed that protect the metal surface from oxidation. Coatings of oxidation-resistant nickel-columbium alloys also will be investigated.

Metal-ceramic composites will receive more attention as high-temperature materials. Some of these materials may be serviceable up to 5000°F. Current research is concentrated on designing new combinations, on understanding the mechanism of bonding between metal and ceramic, and on

TARGET MISSILE, *a Kingfisher, is recovered for reuse after running out of fuel. The ventilated "drag" parachute is used because the sudden shock of air resistance to the heavy missile would rip a standard chute.*

HOT ALUMINA *is blown on coated molybdenum specimens to test resistence of different coatings to heat erosion. Although "moly" has high strength at high temperatures, it oxidizes rapidly when heated over 1000° F. It therefore requires a protective coating for long high-heat.*

developing methods for fabricating the brittle materials.

The production of ultra-pure metals will be the subject of increased research as the year wears on. Metallurgists have found that the properties of metals are changed drastically when the last traces of impurities —even gases like hydrogen—are removed.

One reason for emphasis on pure metals will be an increased demand for very pure materials like silicon, germanium, and selenium for use in transistors and other semiconductors. Chemical companies like Du Pont, W. R. Grace, Monsanto, and Foote Mineral will continue research on improved refining of these materials.

The effect of purity shows up on other applications, too. Some steels have greatly improved strength when they are refined by melting in a vacuum. Allegheny Ludlum was a pioneer in this method of manufacturing special-purpose steels; other steel companies now are developing similar processes.

Melting in a vacuum

A vacuum or an inert atmosphere (that is, with the air replaced by a gas like helium) also is required for refining some of the refractory metals being used in high-temperature alloys. Universal-Cyclops, with Navy support, is building a $3 million molybdenum fabricating plant in which the atmosphere of the entire plant will be pure argon.

Electron beam melting is the newest refining method to appear on the scene. Temescal Metallurgical Corp. is developing this process, in which ingots of the refractory high-melting metals are produced by bombarding the impure metal powder with electrons in a vacuum chamber.

Zirconium, columbium, and vanadium will find increased application in the atomic power industry, for alloying with uranium in reactor cores. The production capacity for zirconium sponge is expected to be some 3,000 tons in 1959—more than three times the 1956 figure.

Improved magnetic alloys will be under earnest development this year. Both General Electric and Westinghouse have announced research on cube-oriented iron alloys, which have superior magnetic properties owing to a more regular crystal structure. Still unknown are the factors influencing the pattern of crystal growth in preparation of the alloys.

In the field of ore reduction, several research teams are exploring methods of reducing iron ore directly with reducing agents like hydrogen and carbon monoxide. One of these proc-

esses, the R-N process, developed jointly by Republic Steel and National Lead, is now in the pilot-plant stage. It is a versatile technique that can be used economically for treating low-grade ore. *(See "Are American Steel Methods Growing Old?" elsewhere in this issue.)*

Computers and components

Next to the aircraft industry, the heaviest area of research spending this year will be in the electrical equipment industry. Again, much of this research is government-supported because of its relation to national defense, especially the missile program. But the large civilian market for electronic appliances will support a significant amount of development work.

Research in solid-state physics, having produced the transistor, now is leading to the development of other new electronic components, such as ferrites (ceramic-like materials with magnetic properties), ferroelectrics, and electroluminescent materials.

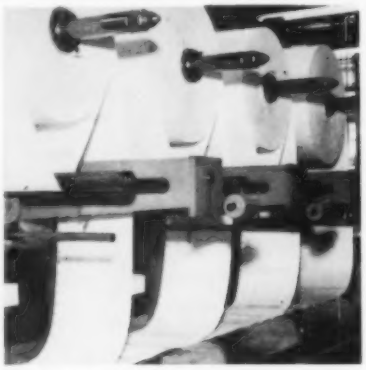
GE and Westinghouse have revealed studies are underway on direct methods of converting heat into electricity. GE's research will be concerned with applications for its thermionic converter, in which a metal-ceramic combination produces electricity when heated in a vacuum.

Westinghouse will develop ceramics from compounds of transition metals that will generate electricity when heated. Westinghouse already has demonstrated how thermoelectric principles makes possible the design of small refrigerators containing no moving parts.

While Sperry Rand's Univacs and International Business Machines' SSEC, general-purpose computers, have been capturing scientific headlines, National Cash Register Co. has been developing machines for specialized uses such as banking. National Cash Register probably will spend half of its $15 million 1959 research budget on computers aimed specifically at the accounting-machine market in small and medium-size businesses.

Another research topic high on NCR's list is its microcapsules, which already are being used in making "carbonless" carbon paper and which, according to NCR scientists, have a host of other possible applications ranging from drugs to chemical memory devices for computers.

IBM is constructing a research center for a staff of 1,500 in Yorktown, N. Y., where research on ferromagnetic and related substances will be a major effort. Other sizable projects will be the design of machines to translate foreign languages and to abstract technical literature. Machines like these *(see an account of the "Perceptron" on page 38 of this issue)* magnify research results by facilitating the interchange of scientific information.



NCR'S CARBONLESS *"carbon paper" has no interleaves of carbon, thus simplifying collating printed forms.*

Evolution in light

Electronics scientists also expect to make progress in electroluminescence, or "EL"—a third step in the evolution of light sources (beyond incandescent or fluorescent light).

Because EL's phosphor-plastic "sandwiches" allow extremely uniform and flexible lighting and direct image intensification, the new light source promises walls of light, drapes of light, picture-frame TV, and safer x-raying.

Westinghouse already is marketing an EL nightlight—a two-inch square panel that will burn a year for less than a penny's electricity—and expects significant breakthroughs during 1959 to develop brighter phosphors. The EL research goal of Westinghouse, Sylvania, GE, RCA, and others will be to increase the ratio of brightness to power consumption—still very low in comparison to conventional light sources.

High-energy fuels

As missiles get bigger and bigger, more fuel is required to launch them. Hence the search for high-energy fuels—fuels that pack more punch. Theoretical calculations show that the performance of today's missile fuels (alcohol, hydrazine, etc.) can be greatly exceeded by chemicals like hydrogen, boron compounds, or lithium. Currently used liquid oxygen also can be replaced by more potent oxidizers—fluorine or ozone, for example.

Chemical companies like Foote Mineral (lithium), Hooker Electrochemical (perchlorates), Olin Mathieson Chemical (hydrazine), and Callery Chemical (boron) will continue researching high-energy fuels. Stauffer Chemical and Aerojet-General have joined forces for research on boron compounds. And Thiokol is stepping up research on solid propellants.

Research in 1959 will involve more exotic fuels. For instance, free radicals—fragments that result when a molecule is broken up—represent an extremely potent energy source that some day may be available for rocket propulsion. Extensive basic research is underway at the National Bureau of Standards on free radicals—how to produce them and how to keep them once they're made.

Fuel cells, in which the energy of a chemical reaction (for example, hydrogen plus oxygen to give water) is transformed directly into electricity, are being studied by several research teams. The research is supported by gas companies, as well as by Union Carbide.

Fusion and 'nuclear' food

Fusion research probably will be the most important of 1959 atomic efforts; it ultimately may be the most significant in the history of mankind. Controlled thermonuclear reactions, using inexhaustible supplies of deuterium in the oceans as fuel, would represent a fantastically cheap source of power.

Research projects underway at Oak Ridge, the University of California, and New York University are concerned with controlling fusion processes by applying magnetic fields to contain the reacting gases and to tap the energy released.

These programs are mostly financed by the Atomic Energy Commission, which is expected to spend a total of

THE AUTHOR

As head of the applied chemistry division of Southern Research Institute and chairman of his local American Institute of Chemists chapter, Dr. Charles E. Feazel is well-qualified to forecast the directions of research for the year at hand. Feazel supervises SRI's research in industrial organic chemistry, plastics, textiles, and chemical engineering. A doctoral graduate of the University of Maryland (in organic chemistry), he has been a chemical and physics research scientist since 1941.

progress report on Aeronutronic

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IRRADIATED *potatoes stay fresh even after six months, while others (left) sprout eyes.*

$2.6 billion for R & D during 1959. (This is $200 million more than last year, and will include $351 million for reactor development and $72 million for physical research.)

The possibilities of peacetime uses of atomic bomb blasts will be explored further this year. The AEC, through its "plowshare" program, has definite plans for excavating a harbor in Northwest Alaska during 1960. Prototype devices will be designed and developed during 1959, together with detailed studies of costs and radiation hazards.

Research on the structure of matter, related to atomic energy investigations, also will progress this year—aided by new particle accelerators. A 25 billion electron-volt proton synchrotron, the largest and most powerful in the United States, is being built at Brookhaven National Laboratory. A two mile-long 45 billion-volt linear accelerator is planned at Stanford University.

Development and design of power reactors, such as the Enrico Fermi plant in Michigan, and the Yankee Atomic Electric installation in Massachusetts, will be supported by electric utility groups.

Industrial Reactor Laboratories—sponsored by AMF Atomics, American Tobacco, Atlas Powder, Continental Can, Corning Glass Works, International Nickel, Chas. Pfizer, Socony Mobil Oil, and U. S. Rubber—will operate its $4.5 million facility in Plainsboro, N. J. The facility includes a 5 million-watt swimming pool reactor and laboratories for each participating company.

Other companies will install their own reactors or irradiation sources. Lockheed Aircraft, under Air Force contract, recently began operation of a test facility at Dawsonville, Georgia, to study radiation effects. North American Aviation plans a $1.25 million building program to expand the facilities of its Atomics International Division.

The use of nuclear radiation to produce chemical reactions will be explored this year. It offers promise as a means of triggering chain reactions that involve free radicals—for example, in the polymerization reactions used in manufacturing plastics. But for most other types of reactions, nuclear radiation now appears to be an inefficient method of promoting the reaction.

The U. S. Army Quartermaster Corps Food and Container Institute will push nuclear sterilization of foods. Its nearly 100 contractors include universities, research institutes, and leaders in the food and container industries. A 2 million curie cobalt-60 food irradiator is planned for installation by the AEC and the Defense Department at the QM's Ionizing Radiation Center in California.

But despite the Army's interest in irradiation sterilization, the food industry appears pessimistic about commercializing the method. Big stumbling block is flavor damage suffered by food when it's irradiated.

Revolution in plastics

The opening of 1959 finds the plastics industry in the midst of a revolution sparked by two recent discoveries. Both of these research advances enable plastics chemists to "tailor-make" polymers, the high-molecular-weight resins from which plastics are manufactured.

One discovery was that certain catalysts—the Ziegler catalysts—for ethylene polymerization are stereospecific; that is, the resulting polyethylene molecular chains have a regular and not a random orientation. This finding has enabled the manufacture of new types of polyethylene (the so-called "high-density" polyethylene) and similar plastics.

The other discovery was that mixed polymers with new and unexpected properties can be made by grafting polymer chains of one type onto a backbone of another type of polymer. This technique will be researched intensively by plastic film manufacturers because grafting offers a means of changing the surface characteristics of the film. Thus it solves problems such as poor printability and high gas permeability of plastics like polyethylene.

One big use of improved plastics films will be in the packaging industry.

Most of the research on polyethylene and other plastics will be carried out by the chemical industry as part of its estimated $670 million 1959 R & D program. Du Pont is reported to have spent $6 million in research on polyethylene alone. Other chemical companies, including Union Carbide, W. R. Grace, Celanese, and Phillips Petroleum, also are investing heavily in research on this plastic. This year will see expanded programs of product development based on Ziegler-type polyethylenes.

Synthetic fibers

The chemical industry spends a sizable part of its research money on synthetic fibers. Du Pont, for one, invests heavily in this field, since synthetic textiles account for 30% of its sales. Celanese also devotes a large part of its $5 million research budget to textiles.

In the past 20 years, the aim of the synthetic fiber industry has broadened from replacing the monofilament silk fiber to capturing the markets for staple wool and cotton fibers as well.

The 2 billion pound per year production of synthetic fibers (nylon, Orlon, Dacron, etc.) is growing rapidly, and new fibers are added to the list almost daily. Recent additions, now in the marketing stage, include American Cyanamid's *Creslan*, Eastman's *Verel* and *Kodel*, Dow's *Zefran*, and Goodrich's *Darvan*.

Some of the most interesting newcomers are fibers (example, Reeves Brothers' *Reevon*) made from polyolefins such as polyethylene and polypropylene. Research on these fibers has benefited from the polymer chemists' work with Ziegler catalysts. During 1959, uses will be explored for screening, upholstery, and tarpaulins.

Another subject of new interest to the synthetic fiber industry is the use of synthetics (nylon, Acrilan, and viscose rayon) in making specialty papers. Improved chemical and electrical properties, and freedom from attack by microorganisms, are the advantages claimed.

Graft polymerization will receive more attention from textile researchers as well as from plastics chemists. This technique has applications in the modification of cotton, as well as synthetic textiles.

Textile consultant Martin Gurley points out that the battle between nylon and rayon for the tire cord market has prompted rayon manufacturers to re-examine neglected research results on improving fibers to give higher strength and longer wear.

'Organic' metal

Chemical researchers during 1959 will pay a lot of attention to chemicals that have received little notice in the past: the organometallics.

continued on page 88

A SEARCHING LOOK INTO AMERICAN STEEL METHODS

It doesn't take an economist to note that the recent American recession was largely a steel recession. Had the dinosaur of industry become so large, so set in its ways, that it lost its ability to adapt and survive?

On the other side of the world, a younger, 40% smaller, dinosaur rears its head and announces expansion plans, radical new steelmaking methods, and a frantic research program tied only to production goals instead of costs. This Soviet dinosaur ought to be watched; it has tripled its size in the last 10 years.

I. B. Austin (shown above in U. S. Steel's research laboratory), has recently returned from Russia. In the following article, he takes a searching look, and brings you up-to-date on the industry that's one of our basic economic barometers.


Are american steel

INGOT MOLDS *sear, smolder as steel is teemed into them at Indiana steel mill much as it has been for half a century in this country. Ingots, historically the first and still the basic shape in steel making, later are rolled and pounded into blooms, billets, or slabs at Midwest mill.*

AN I•R STATE-OF-THE-ART ARTICLE

methods growing old?

While Britain, Sweden, West Germany, France, and Russia develop and adopt the latest steel processes, we cling to our recently-outdated methods—so the press has argued. Here, an authority takes the opposite view on American steel.

by Dr. J. B. Austin
administrative vice-president—
research and technology,
U. S. Steel

It was just a century ago last year that the invention of the converter process, simultaneously but independently, by Sir Henry Bessemer in England and William Kelly in the United States, laid the foundation for the steel industry as we know it today. The event was, of course, widely observed.

But, as is often the case at centennial celebrations,

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An authority on the differences between American and European steel methods, U.S. Steel's Dr. James B. Austin was a member of the U.S. delegation that spent 30 days in Russia last May studying Soviet steel methods. What he has to say in this article will interest industrial executives in many fields concerned with U.S. competitive technology.

Now administrative v-p of research and technology, Austin joined the U.S. Steel Research laboratory when it was established in Kearny, N.J., in 1928. Starting as a physical chemist, he became supervisor of chemistry in 1941 and assistant director of the laboratory in 1944. Two years later he rose to director of research, succeeding the late Dr. John Johnston, under whom he had studied chemistry at Yale. Austin was promoted to vice-president in 1956, at the time the Kearny laboratory was moved to its present location in Monroeville, Pa. Austin was chairman of the refractories division of the American Ceramic Society and president of the American Society of Metals. Currently he is a director of the new American Institute of Mining, Metallurgical, and Petroleum Engineers.

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It was just a century ago last year that the invention of the converter process, simultaneously but independently, by Sir Henry Bessemer in England and William Kelly in the United States, laid the foundation for the steel industry as we know it today. The event was, of course, widely observed.

But, as is often the case at centennial celebrations,

the feast was haunted by a few skeletons which have developed such curvature of the spine that they have assumed the shape of a question mark. Has the steel industry become old and set in its ways? Are there signs of senile decay? Has it, like the dinosaurs, developed a body so disproportionately large compared to its brain that it has lost its adaptability and so has started down the road to extinction?

Unpleasant spectres these, but they cannot be ignored. Self-preservation demands that we face up to them to see whether they have substance. So it is a good time to take a close look at the stature and wisdom attained by this centenarian and to examine the relative progress and prospects of the industry in the United States and Europe.

The matter of growth can be disposed of quickly. The steel industry has become prodigious in size in both areas and is still growing. In 1957, the per capita output of steel was 1,335 pounds in the United States, 1049 in West Germany, 947 in Great Britain, and in the Soviet Union, the world's second largest producer, 562. This list is, in itself, striking but it certainly will become more impressive in the years ahead.

Size isn't progress

But what of the future? Mere increase in size does not insure progress, or even survival. What is required is:

First, sound technological health to engender efficiency in the face of rising costs and dwindling rich raw materials.

Second, a continuing fecundity in producing new or improved products to expand existing markets and to capture new ones.

On the second score, the prospects are reassuring. Long acquaintance with the industry in this country and in Western Europe, and personal observation during a recent visit to the Soviet Union makes it evident to the author that at no time in history has steel been so vigorous in developing new processes as it is today.

There are several reasons for this. Among them are the adoption of progressive management techniques and the reaction of operators to the challenge of achieving better performance in the face of increasing difficulties and competition.

Fountain of research

But perhaps the most important single factor is the introduction of a built-in Fountain of Youth in the form of research. In Western Europe the pattern has been to establish a research organization for the industry as a whole. Thus, in Great Britain, the British Iron and Steel Research Association has extensive facilities and a varied program covering all phases of steel production and use. Its counterpart in France, the Institut de Recherches de la Siderurgie, is engaged in comprehensive work for the benefit of the French steel industry. In Germany, the Max Planck Institut für Eisenforschung is performing something of the same function on a more limited scale.

In the Soviet Union, the pattern differs in that the large central research organizations are run directly by the government, largely under the supervision of the Academy of Sciences. The cornerstone is the Central Scientific Research Institute of Ferrous Metallurgy in Moscow, which has a very sizeable program on steel technology.

In addition, other laboratories, such as those of the Mechanobr Institutes for studying processes for beneficiating ores, are looking into specialized fields. There is also a plant at Tula, near Moscow, which is essentially for pilot production in the development, on a full-scale basis, of new or improved processes for making iron aand steel.

This centralized form of organization has certain advantages. It makes it possible to concentrate maximum effort on any program which the government deems desirable—whether for technical or propaganda purposes. It is, therefore, possible to make rapid progress in selected areas — and to adopt quickly advances made elsewhere in the world.

Adventurous experiments

On the other hand, such centralized direction is not conducive to the diversified and adventurous experimenting which is possible under a more competitive system and which has been responsible for the more spectacular of recent innovations.

In the United States, we have a third pattern which, in my opinion, is the most effective. Although the American Iron and Steel Institute supports a substantial research program for the benefit of the industry as a whole, the major effort is carried out in the laboratories of individual steel companies.

The largest of these is the Research Center of United States Steel at Monroeville, Pa., which incidentally, has one building devoted specifically to fundamental or "learning" research. In addition, the broad program of this center is supplemented by work in special fields done in the laboratories of various divisions, such as Oliver Iron Mining in Duluth, National Tube in Pittsburgh, and American Steel and Wire in Cleveland.

TORTURING TIN CANS—*more steel than tin—goes on at U. S. Steel's Applied Research Laboratory in Monroeville, Pa. Dipping cans in boiling water simulates actual canning conditions.*

Among other steel producers that have well-established laboratories are Armco Steel, at Middletown, Ohio; Allegheny-Ludlum, at Brackenridge, Pa.; and Crucible and Jones & Laughlin, at Pittsburgh. Republic has just completed a laboratory in Cleveland; Bethlehem has announced plans for consolidating its research in a new center in Bethlehem, Pa., and National and Inland are expanding their research programs.

Most of these firms augment their own work with research contracts at universities and research institutes. The total amounts to a very impressive and extensive program, as is evident from the publication of their research results. Moreover, there is a great diversity of viewpoint and emphasis which aids in speeding technical prog-

ress over the whole range of interests of the industry. This competitive research also favors the prosecution of bold or unconventional ideas.

Although these various systems differ, it can be said at once that no one of them has a monopoly on progress. All have made contributions and all stand ready to profit from any new development wherever made.

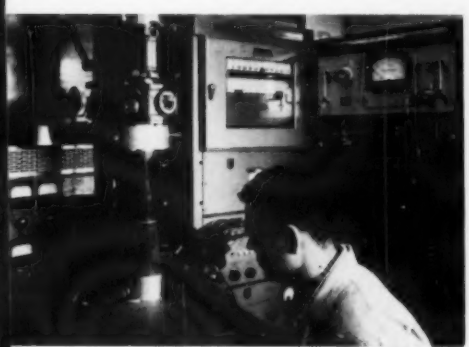
It is interesting to compare the results which have been achieved under these different systems and to check on the progress which has been made and can be expected in the future. In doing this, however, certain differences in the steel industries of these areas must be noted, for they are by no means identical in all respects.

Russian ores are poorer

For one thing, their raw materials are not the same. The ores of the Soviet Union, for instance, are generally lower in iron and higher in silica than are those available to us. Moreover, some are contaminated with zinc or arsenic.

Likewise, the steel industry of Western Europe operates on ores with relatively high phosphorus content. These are factors which have an important bearing on the nature and extent of beneficiation required and on the type of steelmaking process to be used.

FOCUSING ELECTRONS *on a tiny spot of steel causes elements present to emit characteristic x-rays, which can be analyzed quickly.*



Again, the markets in these areas differ. For example, the chief customer of the Soviet steel industry is the Soviet government. And at the present time, there is in the Soviet Union only a relatively small demand for automobile sheets or tinplate for cans, which comprise very important U. S. markets. Even in Western Europe the demand for these products does not match that in the United States, nor are quality requirements so rigorous.

It must be remembered that in the Soviet Union where industrial development is generally so far behind that of the West the demand for steel is so great that *production is the most important goal*. Cost, though not neglected, is certainly a much less significant item than it is for us. As a factor related to costs, labor rates, of course, are much higher in the United States than in other areas, and this has a bearing on the type of process which may be most advantageous.

Keeping these differences in mind, it is instructive to look in some detail at the present status of steelmaking in these various areas. Take mining first. Here is an operation that varies tremendously with local conditions and circumstances — as regards both coal and ore. Nevertheless, considering equivalent conditions, American mining practices are as advanced as any in the world, and in most instances are more efficient in terms of production per employe.

Since other areas have not, in general, been favored with such rich raw materials, they have been forced to make more use of beneficiation and concentration. This is not to say that their methods are more advanced than ours, but rather that they have been practiced on a wider scale.

Russian sintering

The sintering (bonding by heating without thoroughly melting) and agglomeration (mechanical bonding without heat) of ore concentrates by necessity has been carried out in greatest volume in the Soviet Union. This is particularly true of self-fluxing sinter now so widely used in Russian blast furnaces. Such sinters also are being used in this country and will be used to a greater extent in the future.

The use of a high percentage of

BESSEMER FURNACE, *blowing impurities out of iron from blast furnace, is the most dramatic sight at any steel mill, and a proven method of conversion.*

sinter, much of it self-fluxing, as a means of rectifying some of their disadvantages in raw materials has contributed notably to improved blast furnace production in the Soviet Union. A few of their furnaces indeed have achieved impressive performance in this respect. But the best American furnaces also have been setting new production records and can be expected to give even better output as the use of sinter increases. Despite their emphasis on sinter, the Russians, until very recently, have been slow to build the large sintering machines which have proven so efficient in the United States.

The processes used to convert iron to steel vary greatly. In Russia, as in the U. S., more than 90% of the steel is made in the open-hearth, whereas in Western Europe the Thomas converter process is the most widely used. The Soviet open-hearths have achieved impressive performance records which are partly due to the use of "basic" refractories.

These heat-resistant materials also have been used in the open-hearth furnaces of Western Europe and to a lesser extent in this country. In this case, the extent of their use has been dictated largely by economics. The Russians have suitable raw materials close at hand for manufacturing the basic brick, whereas we must import some of them so that for us they become much more expensive. Moreover, as noted before, the possiblity of getting increased production from their use makes them attractive to the Russians in spite of cost.

THE CREEP OF STEEL—*its slow extension when loaded at high temperatures—is measured with precision.*

Oxygen for speed

The use of oxygen for increasing the speed of steelmaking furnaces is widely practiced throughout the world. The potential improvement from the use of oxygen was first demonstrated 35 years ago in American open-hearth furnaces. However, at that time, oxygen was available only in pressurized bottles and at a prohibitive cost.

Today there are many large oxygen plants capable of producing more than 500 tons of oxygen per day, and at a cost of less than one-tenth that of 35 years ago. Thus it is not at all surprising to find that many American steel plants now use several thousand cubic feet per hour of oxygen in a single open-hearth furnace.

Russian and European steelmakers, however, are just as aggressive as we are in using oxygen to increase the speed of steelmaking furnaces.

Another development which is attracting considerable attention is the use of oxygen in top-blown converter vessels. This appears to be useful under some conditions in the production of carbon steels. It seems especially advantageous under European conditions where air-blown Thomas converters, which account for half of the total steel production, can be adapted easily to the use of oxygen blown from the top.

It is being practiced to a lesser extent both here and in Russia where open-hearth furnaces account for about 90% of the total steel production. The Russians expect to expand its use but believe it won't account for more than 10% of their total steel production. Its use in this country may be expected to increase as well.

Combined blast and open

In the shaping and fabrication of steel, American methods of heating, rolling, and annealing are certainly

STEEL RESEARCHING *involves many sciences, especially chemistry. A tar and pitch technician here experiments with various binder materials used to strengthen big graphite electrodes of electric furnaces without contaminating the melt. The pitch-graphite electrodes, often a foot in diameter, melt up to 50 tons of steel at once.*

VACUUM CASTING *to prepare special alloys is carried on experimentally in this 50-lb. capacity furnace. In U. S., says author, steel researchers can study such processes until they become economically feasible. The Russian's stringent materials needs, however, make production—not cost—the only factor worthy of consideration in U.S.S.R.*

hearth furnace system continues to be basic in U. S. steel industry.

more advanced than those used anywhere else in the world. This is, in part, a result of the fact that the American market for such products as sheet and tinplate is the largest, and that quality requirements are higher.

In the production of coated products, American practices also are superior. American methods for making electrolytic tinplate are being used all over the world, and in the newer field of plastic coatings we are clearly ahead.

All of the methods discussed so far are chiefly refinements on what might be called standard methods of making iron and steel. But what of the more unconventional processes now under consideration? Here again, the American steel industry is progressive and aggressive though it certainly has no monopoly on such devices.

Bypass the blast furnace?

A good example is so-called direct reduction; that is, the production of iron without melting as in the blast furnace. There has been a great deal of misunderstanding about the usefulness of such processes and about what they aim to accomplish. Primarily, their role is to supplement the blast furnace — not to supplant it.

In an integrated steel operation, direct reduction offers a substitute for purchased scrap or a feed to an electric furnace rather than the main charge for an open-hearth. Direct reduction, therefore, is more attractive in areas where scrap is scarce, as in Mexico and some parts of Western Europe, than it is in the United States, where scrap is more plentiful.

Moreover, there are many different ways in which direct reduction can be carried out, each having certain potential advantages under special conditions. One method, for example, is to reduce the ore in a fluidized bed by means of a gas such as hydrogen. The fluidized bed technique — in which fine particles virtually are suspended in a stream of gas so that the mass takes on many of the properties of a fluid — is an excellent way to carry on some kinds of chemical reaction. It has been brought to a high stage of development by the petroleum industry in this country.

A direct reduction process for iron based on this procedure appears to be well suited technically for use with fine high-grade ores or concentrates. This suggests that it should be suitable for some of the raw materials which the American steel industry now is using or may have available in the near future.

In fact, at least three programs are under way in the United States to adapt such methods to the reduction of iron, but their economic attractiveness remains uncertain. For one thing, the cost of the gaseous reducing agent is relatively high.

A small commercial plant using this technique primarily to produce a specialty product, iron powder, is being put into operation by the Alan Wood Steel Co. and may yield more information on this matter.

Western Europeans have not shown as much interest in this approach. The Russians say they're investigating it, but believe it will be useful only in special situations and is not likely to be a significant factor in their steel industry.

Other methods of direct reduction use a rotating kiln or some similar type of furnace. Some of them seem especially well suited for the reduction of lean ores with relatively low-grade coal or other source of solid carbon. This makes them particularly attractive under European conditions, but they are being investigated in this country as well.

It should be noted that the product of any of these direct reduction processes is not in a form which is directly usable, except in small special applications. It is not completely reduced to iron and contains an undesirable amount of the original gangue material. Thus, it must be given some further treatment which usually can be done most conveniently and economically in conventional steelmaking equipment.

It is for this reason that direct reduction should be regarded as an adjunct to, rather than a replacement for, our present methods. Such practices no doubt will prove suitable for special purposes and they will find their place in the steel industry in the years ahead, but as yet they have not been widely adopted in any country. Their development is as well advanced in the United States as anywhere else, however.

Eliminating prime rolling mills

The continuous casting of steel to avoid the present necessity of primary rolling mills is another matter of great current interest. Developments in this field have been made concurrently in both America and Europe. The process is best adapted to small tonnage production and is, therefore, more attractive in Europe than here.

Nevertheless, a number of experimental units have been built here and a small commercial plant is in operation in Canada. Their performance certainly indicates that it would be uneconomical to scrap existing facilities in order to replace them with

equipment for continuous casting. The Russians have a pilot machine of this kind, of essentially European design, at Tula. They state they're building larger units, but they don't expect to use this process for any significant part of their total production.

Another recent innovation, the vacuum pouring of steel ingots, is well advanced in both Germany and the United States, and commercial units are in operation in both countries. Its use certainly will grow. Just how much the Russians are using it is uncertain, but they *are* studying it.

Although not strictly a matter of production, there is one important area in which the American steel industry excels, and that is safety. Our record is impressive, especially when compared with those of other countries. On a recent visit to the Soviet Union, for example, I saw not one safety hat or pair of safety shoes.

They only 'look' the same

It often is difficult for non-steelmen to appreciate how greatly methods of making iron and steel have improved because a steel mill today has much the same appearance as it did many years ago. Yet a look at production records and costs indicates a great difference. One reason for this is that there is now, and has been for some time, a premium on getting more production and better product from existing equipment.

The story of how depreciation allowances have become increasingly insufficient in the face of continuing inflation has been well publicized, but its effect on steelmaking methods is not so well appreciated. Take the blast furnace. It's bigger than it used to be but it still looks essentially the same. You can't readily see the beneficiated and sintered burden or the other devices which have contributed so much to greater output.

Likewise, the open-hearth seems at first glance to be bigger but otherwise unchanged. But you must take a closer look to see the various ways in which the use of oxygen has improved the efficiency of the process.

And a close look at our rolling mills will reveal how much they have benefited with respect to output and quality of product by the use of automatic controls. All these things are making their contribution to American production.

Some concrete examples:

■ During the last seven years, blast furnace production has increased 11% with an increase of less than 5% in the number of furnaces.

■ In the past few years, production of open-hearth furnaces of the United States has increased 22% with a slight decrease in the number of furnaces. At the same time there has been an increase in the uniformity and quality of the product.

These advances are not due merely to the construction of larger furnaces. A much more important factor is an increase in our understanding of these processes with consequent greater efficiency of operation. Yet this is only a beginning. Still greater improvements in steel technology are in prospect which will include even better and more efficient methods.

American steel methods are not growing old. They're becoming more youthful every day. ■

EDITOR'S NOTE: *So that we may serve you better in future issues, we'd appreciate a postcard or letter ranking your interest in this and the other articles you read. Results will appear in a "Letter to I•R" column.*

IDEAS FLOW *best in informal atmosphere. American steel, lacking national, centralized direction, says author, leads to "adventurous experimenting."*

comment

continued from page 10

the remodelling job) is so what? It sounds a little like the ridiculous and frantic assurances that our science is better than Russia's.

If we have to counter the Russians' obvious success in nuclear and thermonuclear science, jet aircraft, and space technology, let's do it, for instance, by filling in more of the gaps in our knowledge of the atomic nucleus, not by bragging about the tool designed for that job.

Market potential

Foster D. Snell Inc. tells us that each pound of the annual 1½ million tons of new rubber consumed in the U. S. is accompanied by roughly two pounds of other materials—such as activators, inhibitors, stabilizers, etc.

The opportunity here is to discover the vast rubber-associated market for your products, byproducts, or future products.

Foreign plastics

Some 60,000 pages of Soviet scientific and technical journals now are available in English translations. Some of them tell of research and production of plastics, which now is running to about 30% of U. S. totals.

Khrushchev has announced an all-out effort for increasing plastic production to 120% of U. S. totals. If this happens, Soviet plastics would satisfy Russian needs and upset world markets with the excess.

Meanwhile, further expansion of plastics and synthetic rubber industries in Japan is foreseen as a result of close technical cooperation between American and Japanese manufacturers. A new styrene monomer plant now under construction by Asahi-Dow, is expected to go into production early in 1960.

Wonder metals

We've been wondering about one of the "old" wonder metals, titanium. Once publicized as a cure-all, titanium sales rose a little and then fell into a complete slump because of military cutbacks.

Stoetzel & Associates, a marketing firm, expects the titanium industry to get in full swing about five years from now.

Aside from applications in the now-arrived commercial jet age, titanium's remarkably high strength-to-weight ratio will find many applications in high-speed rotating and reciprocating machinery.

In addition to all the old wonder metals, our bid for a new one is old-fashioned aluminum. The nation's aluminum die casting foundries have a tremendous market potential in the automotive, tool, office equipment, and appliance fields.

Thulium, 99% pure

The availability of thulium and samarium metals of 99% purity in lump or ingot form has been announced by Research Chemicals Inc., Burbank, Calif., a division of Nuclear Corp. of America.

These rare earths have not been commercially available previously. Thulium is superior as a radiographic source to the formerly used thulium oxide. Samarium is of interest in reactor programs because of its high cross-section (5,500 barns).

Ocean of expansion

Instead of worrying about dwindling fossil fuel reserves and radioactive nuclear plants, power engineers will be able to supply this country with free

"She remembers attaching the Swambat papers together with a paper clip."

comment . . .

hydrogen fusion power from sea water. Americans will be able to have an almost completely automated life at low cost.

All this before the end of the century, according to the Public Service Electric & Gas Co. in New Jersey.

There are, of course, other dramatic possibilities latent in the oceans, should the above prediction prove overoptimistic:

■ Seaweed, with its exceptionally high vitamin content, should begin to provide food for both man and animals—and soon. Recent experiments indicate that livestock thrives on seaweed meal. Milk production increased in cows and the vitamin A content of their milk was greater. Hens laid better eggs; pigs fattened quicker; turkey mortality was reduced; etc.

■ Loose-lying metal-bearing rocks are worth an estimated $1½ million per square mile in some areas. These deposits and ways to recover them economically are being investigated by mineral engineers at the U. of California.

■ Scientists at Plymouth, England, have found appreciable quantities of the strategic niobium and vanadium in the flesh and blood of ascidians, a sea animal such as the skate.

Shades of sputnik

Recession sales were double those for all of 1957 for Products Design Co., Redwood City, Calif. This small firm makes practical classroom teaching aids to demonstrate basic scientific fields.

Example: a hydroelectric dam kit complete with six-gallon reservoir and a six-volt turbine generator.

Upgrading engineers:
a special report

At Stanford U. this year some 400 engineers and scientists employed in nearby industry are attending regular daytime graduate classes to work toward advanced degrees. They take about 40% of a normal course, sit in classes on their companies' time, and study when their fellow employes are relaxing after hours.

They are members of a unique industry-university plan, the Stanford Honors Cooperative Program in Engineering and Science.

During the past decade a blue chip R & D community has formed on the San Francisco peninsula around Stanford. Because it ordinarily costs Stanford twice as much to teach a student as it collects from him in tuition, these companies kick in a sum equal to the tuition paid by the students.

So far, 27 organizations are participating on a five-year basis:

Ampex, Dalmo Victor, Detroit Controls, Dymec, Eitel-McCullough, Federal Pacific Electric, Food Machinery &

continued on page 83

Uncooperative Research

HUMOR **by Robert W. Keehn**

Forming a good case for proponents of cooperative research are history's several basement inventors whose inspiration sprang from misdirected genius or downright moon madness.

A humane gentleman of the early 1900s devised an unusual mousetrap for which the world beat no discernible path to his door. The trap actually was designed to fasten a small bell around the nosy victim's neck instead of killing him.

In theory, the mouse would scamper back to the nest, and the bell would panic all his companions into fleeing from the house—still alive, but doubtlessly scared right out of their appetites.

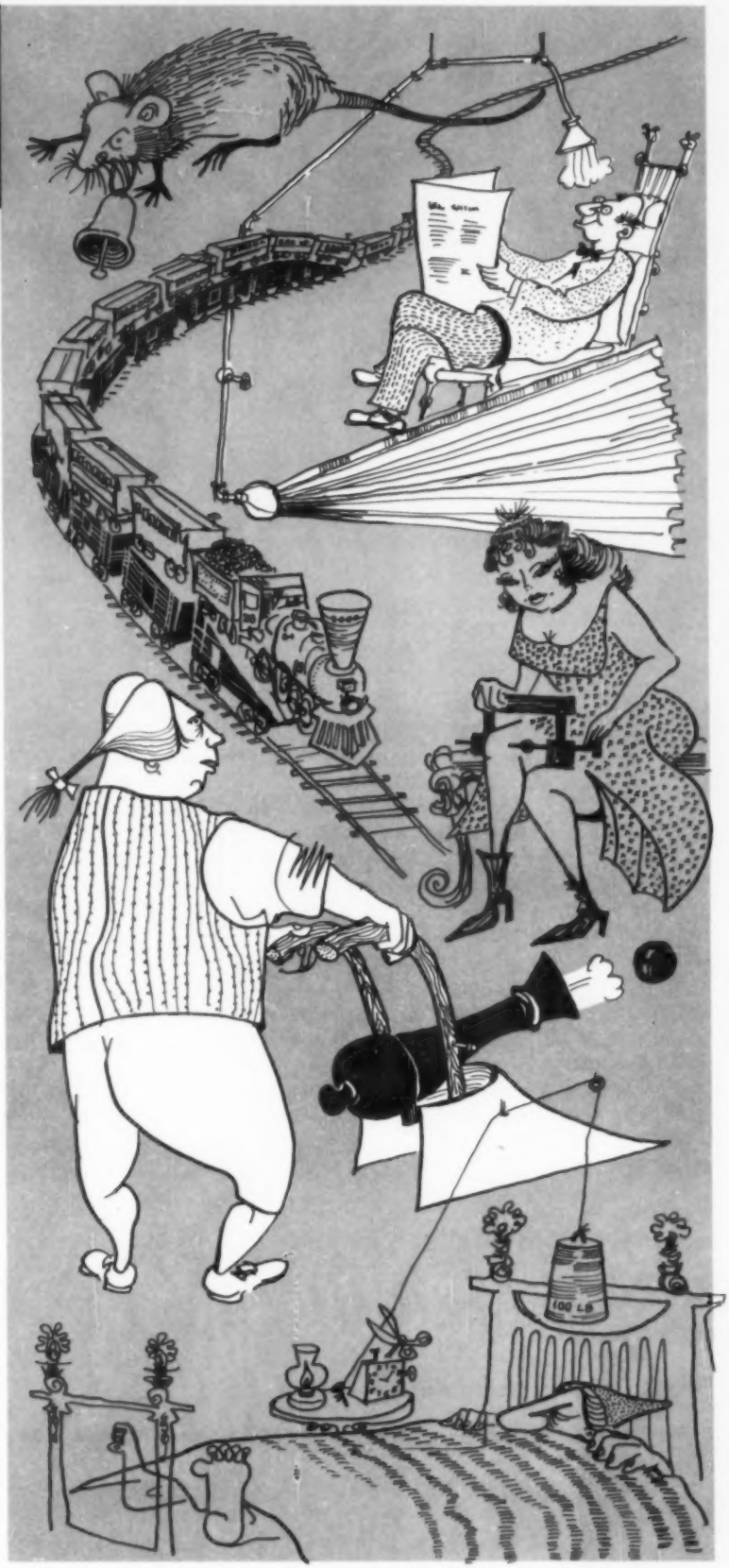
To allay any doubts as to the trap's effectiveness, the inventor added this reassuring note: "*. . . thus practically exterminating them in a sure and economical manner.*"

The cannon-plow

If you lived in rural areas in 1862 where renegades, Indians, and such made your life miserable, a must was the combination plow and cannon. With it, you could disperse the rascals with ridiculous ease, and never miss a furrow.

The designer's classical remark:

R and D



"Its utility as an implement of twofold capacity is unquestionable." Any questions?

Modern railroads, bedeviled with rush-hour problems, might ease the strain by borrowing from another old research development. The design called for the first and last cars of a train to be built with roofs that sloped right down to the track level. All of the cars would be equipped with railroad tracks on top of them.

Then, when the highball express overhauled a local, there was no need for such tiresome things as sidetracking or slowing down. The express simply leapfrogged over the top, via the rails and continued on its way—probably with such a heart-stopping roar that occupants of the overpassed local seldom would use the second half of their round-trip tickets.

Rockerless rocker

For those who looked to the rocking chair for genteel recreation, a *circa* 1869 invention boasted of being a rockerless rocker. A bellows-like contraption replaced the rockers. This prevented you not only from *"rocking on children,"* but offered a second distinct advantage:

A flexible pipe suspended over the rocker's head directed the exhaust from the bellows in a cooling breeze upon his brow. This alone made it well worth the cost.

Slumberers of the 1880s who had trouble awakening could rely on another odd contrivance to rouse them. Resembling a murderous mobile, the whole affair could be dropped nicely into the sleeper's face at a specified time. Caution:

Be sure construction is such that *"it will strike a light blow, sufficient to wake the sleeper, but not heavy enough to cause pain."*

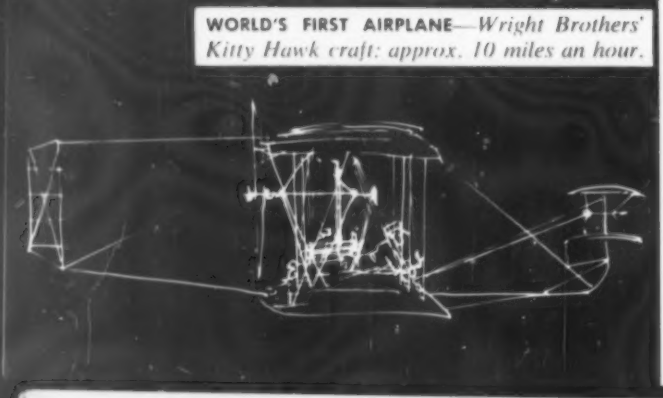
Voila!—a dimple

Gay Nineties beauties were offered a sure-fire way of acquiring much-to-be-desired dimples. A marvelous device that looked suspiciously like a carpenter's brace-and-bit claimed to do wondrous things.

Merely place the rounded end of the bit where a dimple would be most devastating, and turn. In no time at all, the skin would soften, relax, and —*voila!*—a blister.

Whether these attempts were serious or made with tongue in cheek is hard to say. But whether anyone should laugh them off can be argued too. After all, a lot of jaws sagged when a flying machine that wouldn't fly flew very well, and catapulted the Wright Brothers into a lasting spot in history. ■

WORLD'S FASTEST JET — *Lockheed's F-104 Starfighter: exceeds 1,400 miles per hour.*



WORLD'S FIRST AIRPLANE—*Wright Brothers' Kitty Hawk craft: approx. 10 miles an hour.*

Part 1: AIRCRAFT

(In next issue—Part 2: SPACECRAFT)

by K. M. Wylie Jr. AN I·R CONTRIBUTING EDITOR

the FLYING

From Kitty Hawk to melting wings
machine is a rocket ship,
A case in point is the

LIKE A FICKLE SUMMER LOVER who has discovered the joys of October, man is forsaking the Air-Plane he so recently invented. In terms of his fastest flying craft, he already has built the last true *air*craft. And the gathering swarm of VTOL (Vertical Take-Off & Landing) machines shows he no longer depends on *planing* to get or stay aloft.

In our highest-performance planes we simply are flying too fast for the air. We have learned how to build supersonic and hypersonic craft. We are getting them up and out of the dense air to increase speed, to save fuel, to outrace the enemy.

Between the supersonic speeds of Mach 2 and 3 (two and three times the 680 mph of sound), skin temperature rises from 200° F to 600° F, and heat problems, caused by friction of air against aircraft structure, begin. Between Mach 6 and 30, air becomes a Mr. Hyde. No longer the familiar atmosphere, it's a new, unknown medium. The effect on flight is considerable.

For long-range commercial flights and combat purposes we must fly faster and faster. Aircraft wings grow thinner and stubbier to reduce drag. North American's *X-15* research rocketship, a flying tube, has wings described as cleaver blades. It's built to fly 3,600 mph at an altitude of 100 miles, but may reach 4,000 mph and 300 miles.

Lockheed's *F-104 Starfighter,* world's fastest and highest-flying combat aircraft (actual top speed is secret), could well be considered one of the last true airplanes. Operating efficiently at 70,000 feet, well into

PART OF THE NEW ERA IN FLYING *is toward "personal" aircraft, which may become almost automobile-common. Here, the Gyrodyne XRON-1 Rotorcycle, developed for the Navy, shows how commuting could be both faster and more interesting. A 60-hp Porche (auto) engine powers coaxial rotors to carry a single person 70 mph.*

MACHINE: a new era

was only a few years. What's next? Today's fastest flying and even the atmosphere-bound craft is undergoing a revolution. newly researched Vertical Take-Off and Landing aircraft.

the stratosphere, it has a wingspan of only 21 ft. 11 in. and a leading-edge-surface radius of 16/1000 in. Its Mach-2 speeds of 1,400 mph and more, plus high thrust-to-weight ratio, make the thinness essential. And to make them thin, the wings have to be short, an aerodynamic must.

Design problems such as this one are symptomatic of the current era of the flying machine. An important, official recognition of the new era was the transfer last Sept. 30 of the facilities, personnel, and research activities of the National Advisory Committee for Aeronautics to a new organization, the National Aeronautics and Space Administration. Creation of NASA was by order of the Space Act, signed by President Eisenhower July 20, 1958.

Back here on earth, the flying, mailing, and cargo-shipping public is demanding that air transport come closer and closer to the source of business, dropping precisely into congested downtown areas and onto skyscraper rooftops. Even outlying airports are reaching the limit of their extension of runways. Barriers are both natural and financial. Merely modifying the

Los Angeles International Airport to receive jet transports, for instance, is costing about $60 million.

Nuclear warfare also would demand both civilian and military air transportation which could get into the air from any rough field or highway remnant. Literally the only direction certain types of air transport can afford to go is up; that is, straight up and straight down.

Vertical vehicles by the dozen

The answer is VTOL or STOL (Short Take-Off & Landing) craft. But achieving S/VTOL flight characteristics isn't cheap. Adding Mach numbers to the performance of combat craft has cost dearly, and we have paid it willingly. We also will have to pay it for the flexibility of vertical ships.

The basic S/VTOL problems—vertical stability and foolproof transition to horizontal flight—are knotty ones. Hence, there are at least two dozen S/VTOL types currently under development in the United States—propelled by rotor, propeller, ducted-fan, or turbojet.

In addition, there are the helicopters with their great, flailing rotors—although the 'copters are sometimes separated from the rest of the strictly VTOL flock, because the latter, in switching most or all of their thrust forward, actually can become high-speed horizontal-flying aircraft. Helicopter top speed forward is limited to about 160 mph.

The flying saucer

And, of course, there is the flying saucer. Reports say that Avro Aircraft Ltd. of Malton, Ontario is working on a saucer project. Avro has said little about the project, but some reports have it that the craft will be ultra-fast, about 40 ft. across, and spun through the air by a gas turbine with peripheral power vents.

Aviation specialists actually are not agreed on the *ideal* type of abbreviated takeoff and landing. Should it be pristinely vertical, as in the true VTOL?

Or are the brief rise and fall of the STOL craft good enough? Certainly they're cheaper. This is true of both fuel consumption and engine size. (STOL performance means clearing a 50-foot-high obstacle 500 feet or less from takeoff.)

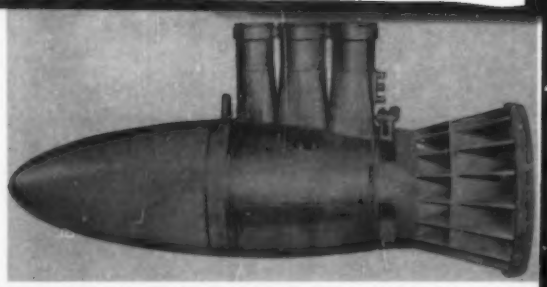
Figures show that the payload of a VTOL craft has to be 50 to 60% less than a comparable STOL plane because of the vertical model's greater fuel requirements. And what airport, the STOL advocates ask, doesn't have at least 500 feet for landing and takeoffs?

The main advantage of vertical-takeoff-and-landing is just that, its verticality. There *are* extremely crowded ports and rooftop-sized landing spaces around our cities as well as hellish military situations which plainly do demand the sheer rocket rise converting to the comet getaway.

But whether it's VTOL or STOL, abbreviated takeoff craft will end airplane stacking over major airports, save the weight of the 60% extra fuel carried as standby supply for wheeling, and add extra insurance that the airliners always would meet their schedules. Lockheed is to start work this year on a 2,000-mile-an-hour VTOL jet airliner.

Some S/VTOL transports already are flying. One, at least, is about to go into commercial service. It's the 48-passenger *Fairey Rotodyne*, a type of convertiplane built in England. Okanagan Helicopter Group, Vancouver, Canada, already has ordered a Rotodyne for intercity service. (Kaman Aircraft Corp. is U.S. licensee.)

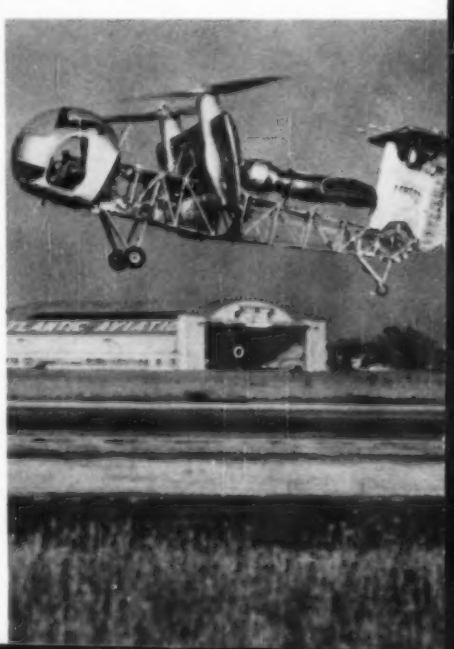
Called the world's first VTOL transport, the 200-mph Rotodyne is probably the most fully perfected of the S/VTOL transports. Typical schedules,



TIP JETS *mounted at ends of Fairey Rotodyne rotors give blades extra thrust. The baffles silence locomotive-like exhaust chugs of the kerosene units.*

FIRST OPERATIONAL VTOL AIRLINER, *the British Fairey Rotodyne, seats 48 passengers. Two 3,500-hp turboprop engines pull it horizontally for speeds of almost 200 mph. The 90-foot rotor lifts and lowers the craft vertically.*

TILT-WING *prototype, the Vertol 76, rises vertically, pulled by twin props powered with a single engine. Wing pivots for transition to horizontal flight.*



THE AUTHOR

To get this story on the state of aerodynamic art, I•R contributing editor Ken Wylie talked during the past six months to dozens of "flying machine" researchers and literally condensed 1,000 pages of research reports. Wylie has concentrated on science writing since his graduation from Northwestern (MSJ) in 1952, and has held staff editorships on Popular Science, Science and Mechanics, and other magazines. Among his current duties at Armour Research Foundation, he edits the Industrial Research Newsletter publication.

city center to city center, would be Cleveland to Detroit, 40 min.; New York to Philadelphia, 36 min.; London to Paris, 80 min.

Yet, since the Rotodyne has been under development for some time and is mainly a standard plane with a 'copter rotor, it's also less advanced than some other vertical vehicles.

Probably the nearest of all 'copters to being a true commercial transport is the *Vertol 107*. A dual-rotor amphibious helicopter (scheduled for commercial delivery in 1961), it seats 23 to 30 passengers. The Army has ordered 10 of them as troop carriers. Vertol believes the ship stands a good chance of becoming the helicopter era's "DC-3."

While tail-sitting propeller projects such as Convair's *XFY-1* and Lockheed's *XFV-1* now seem to be surrounded by silence, Ryan in 1957 flew its *X-13 Vertijet*. This is a jet intercepter-type which takes off nose first and backs down on its mighty jet blast, hooking its nose onto a gantry cable for the last few inches to touch-down.

According to Ryan, in the time a conventional jet fighter becomes airborne at the end of a 15,000-foot runway, a Vertijet can climb 15,000 feet high, ready for action. Also, because the Vertijet's wing size isn't determined by landing requirements, it is much more maneuverable than standard fighters in the air, turning in about one-fourth their radius. Ryan now plans a supersonic Vertijet fighter or fighter-bomber.

In mid-1957 the U. S. Army's Transportation Research and Engineering Command assigned contracts for building prototype airborne cars or flying jeeps to three firms: Piasecki Aircraft Corp., Chrysler Corp., and a Curtiss-Wright subsidiary called Aerophysics Development. What the Army wants (but doesn't yet have) is a flying vehicle that can lift 1,000 pounds —and weigh only 500 pounds more than that.

Piasecki, the first to get its product in the air, built a wingless vehicle to fly extremely low — hugging the ground of battle areas, ducking under bridges and wires, skimming stealthily behind trees and hills, landing and running along on its powered wheels. Improved and renamed the *Sky Car, VZ8P*, it is claimed to be the first vehicle to fly both vertically and horizontally powered by small rotors entirely within the body.

Chrysler's solution to what must have been its maddening problem of getting an automobile to fly has been shown as a slightly pointed flying platter. It's a kind of 20 x 10-foot aircraft with wheels under the belly and cockpits on top, flanked by twin rotors powered by a 350-horsepower aircraft engine.

The Curtiss-Wright flying jeep apparently will use both ducted fans—for vertical lift—and propeller(s) for going forward.

AUTOMATIC CONTROL *for helicopters has been perfected by Sikorsky, allowing pilots hands-off freedom during flight — something not possible before. System helps make all-weather helicopter service feasible.*

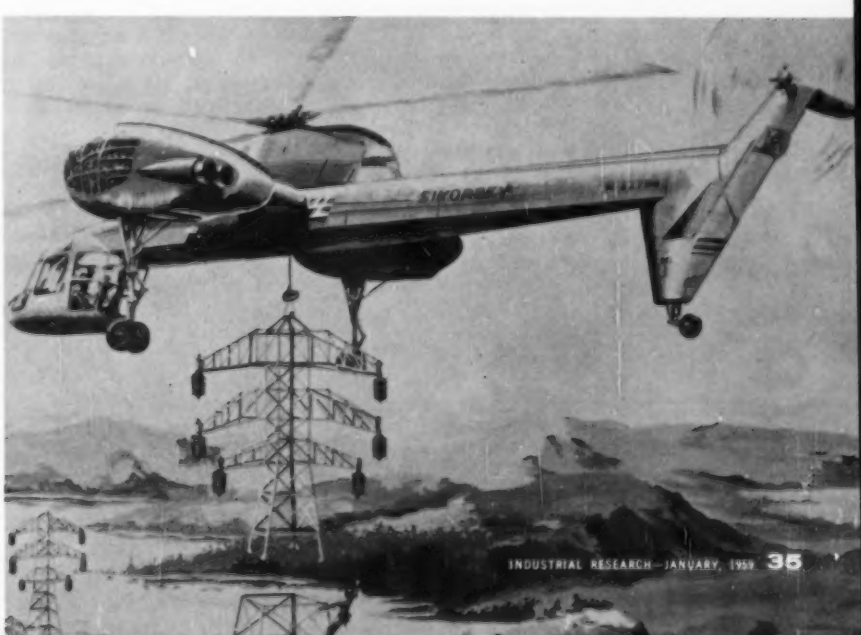
TRIPOD 'COPTER, *the Hiller XROE-1 Rotorcycle, seats one, folds into small bundle that can be carried by a Marine. Upright 4-cylinder engine (which serves as backrest) drives helicopter at peak 70 mph; 12,000 ft.*

Wings that blow on themselves

Fixed wings, despite such examples as the flying furniture and airborne cars, are not being entirely abandoned. Instead, some designs actually use wings to spread wide the main propulsive power, channelling jet-engine exhaust there instead of spewing it out.

A variation of this jet-wing system is the flap-blowing high-lift method which increases lift during takeoff and landing by blowing a thin sheet of air at the wing trailing-edge. Researchers now have discovered that sending this air sheet over a mechanical flap gives more lift than blowing it free.

In some configurations it is believed



A FLYING CRANE, *the Sikorsky S-60, now under construction will hoist and carry loads up to six tons when completed early this year. Control of the craft will be precise enough to build high-tension towers, as shown. A rotating pilot's seat and extra set of controls enable "crane operator" to face either way during loading or unloading.*

WING TILTS *on Hiller's new X-18. Just unveiled, it's a VTOL, STOL, or fixed-winger—depending on runway length available.*

that the jet-wing or jet-flap system could multiply wing lifting capacity four or five times. While this method cannot lift a ship perpendicularly, it could, in theory, get a transport comparable to the DC-8 or 707 off the runway in a tenth the normal takeoff run.

Jet-wing methods also suppress jet noise, especially when engines are enclosed in flattened housings mounted over the wing as in Martin's *P6M SeaMaster* flying boat. Exhaust roar could be lowered 30 decibels by this method except in the highest frequency range.

As you read this, if research and testing have proceeded on schedule, construction will just be starting on the actual test vehicle of Fairchild Aircraft Division's *M-224-1 Fledgling*. A single 1025-horsepower gas turbine engine, geared to spin four propellers, will power this high-tailed S/VTOL research vehicle which is designed to prove vectored-slipstream principles.

The wing's large, articulated double flap, plus the all-movable horizontal tail and hydraulically powered double tail fan (for yaw control) should give the Fledgling the kind of highly flexible VTOL action needed for a tactical, vertical-flying transport.

Main advantages of the Fledgling-type vehicle is that it combines the best of vertical-flying characteristics with the high-cruising speed of fixed-wing planes. And with a bigger-than-normal passenger or cargo load it could still give good STOL performance.

Wings that tilt

Fixed wings traditionally are the best way to haul the heaviest loads in the air. Indications, based on test-bed and prototype performance, are that the best S/VTOL load carriers are not the ones which throw the wing away but merely detach and readjust it—the wing-tilters or thrust-tilters.

At least two projects are outstanding in this category. Vertol Aircraft Corp.'s Model 76 (Army VZ-2) was the first of the tilt-wings to fly successfully. And Hiller's X-18, weighing 16½ tons, is the first transport-sized VTOL aircraft built in this country. The X-18 was unveiled last month.

Developers of tilt-wing models see it as a triple-type aircraft: (1) Flying as a standard fixed-wing airplane with the wing horizontal. (2) As an STOL ship with the wing adjusted. Or (3) as a true VTOL ship, landing and taking off vertically, pivoting the wing full and shifting to horizontal flight for a cruising speed of 300 to 450 mph.

Of all VTOL types, the wing-tilters look best for carrying the heaviest cargo loads; they also should perform well for interurban airline service at ranges up to 500 miles.

Nor are these few examples all of the vertical/short flying story. Both spurred and perplexed by the realization that so many roads lead to the sky, vertical aircraft researchers seem determined to perfect, create, and jury-rig such agglomerations of machines to take us there that the S/VTOL movement has gotten the look of a gadget carnival. Most of these strange machines, keep in mind, are test-bed projects.

But if there are any doubts about the commercial feasibility of vertical flight, the prime assurances are the rotary-wing craft—the helicopters.

Robot 'copter

Kaman has built a radio-controlled robot helicopter which has hovered, flown forward, backward, sideward, and landed, suggesting possibilities for the development of 'copter drones and guided "heli-missiles."

Sikorsky Aircraft Division's ASE unit (automatic stabilization equipment) operates both as the auto-pilot in a fixed-wing aircraft and makes automatic corrections of flight characteristics during manual flying.

Also at Sikorsky, development of an all-weather helicopter should end the general belief that helicopters never would be suited for instrument flight and, therefore, commercial timetable service. Part of the new weather-be-damned dependability stems from the use of ASE; part, from a combination of altitude and speed-measuring radar, better cockpit control arrangement, automatic engine RPM controls, and an automatic hover coupler.

Industrial Pegasus

Helicopters are fast becoming industrial workhorses—or skyhorses. New jobs for helicopters are about as numerous as new jobs. They're used for inspecting transmission lines, laying out water hoses for forest-fire fighting, sowing rice and dusting cranberry bogs with insecticide, dropping water or "firebrake" bombs on forest fires, rescuing stranded mountain climbers, towing water-skiers, extirpating Army trucks from the mud, and photographing stone masons repairing the Washington monument.

Big industrial loads will be going by helicopter before long. Gyrodyne Company of America envisions an amphibious *Model 30 Flying Crane* with a compact axial-rotor-engine arrangement totaling 28,000 hp. Capacity would be more than 100,000 pounds carried either in suspended cargo pods or cinched firmly beneath the crane's fuselage.

Sikorsky's crane helicopter, the *S-60*, scheduled to fly early this year, will carry six tons in a pod or slings. Its pilot, sitting in a swivel seat, will work at either of dual sets of controls, depending on whether he's facing front or rear during loading and unloading.

Simpler methods of pushing rotors around have long been needed as replacements for the helicopter's complex gearing, shafting, and remote engine placement. Hiller has used ramjet tip-propulsion. Kaman has tried driving a Boeing compressor off the main turbine engine, then ducting compressed air to the blade jet nozzles.

In a third method, used on the *Monte Copter Model 12*, compressed air blasts through 38-inch slots near the 32-foot blade's tips.

Personal flying

One of the surest signs that the end has come to the old age of airplanes is the rise of personal flying, propulsion by means of the one-man machine, the intimate aircraft. At least four projects are notable in this area.

Gyrodyne's *XRON-1 Rotorcycle*,

developed under Navy contract, weighs 350 pounds, flies 70 mph at a maximum ceiling of 12,000 feet. Hiller's *XROE-1 Rotorcycle*, completely foldable, weighs 300 pounds, reaches a peak of 70 mph at the same altitude. Bensen Aircraft's *B-8M*, driven by a two-cycle, four-cylinder McCulloch engine developing 72 hp, has a mechanical drive for spinning the rotor at flying speed before the takeoff run, reducing runway distance to less than 50 feet.

But nothing could be more *personal* certainly than the system for flying by strapping to the body the Buck Rogers rocket belt developed in the Army's project Grasshopper by Reaction Motors Division of Thiokol Chemical Corp. Whether this should come under the heading of air*craft* perhaps awaits a better definition of power plant or fuselage.

But not only have the belt's testers sprinted for several seconds at 35 mph without tiring, but they have broad-jumped 20 feet, and shot up eight feet under rocket power from a standing position. Bell Aircraft also is believed working on a belt.

At the other extreme from these al fresco machines are two of the most advanced, facile-looking of all S/VTOL aircraft, one American, the other British.

The *Bell X-14* takes off horizontally, hovers, and settles to the runway vertically. The 3,000-pound thrust pushed by the X-14's two turbojets blasts over venetian-blind-style vanes built into the engines' exhaust area and is deflected down to give vertical lift. For transition to forward flight the exhaust blasts rearward. The usual rudder, elevator, and aileron control surfaces have little effect at the slow forward speeds of vertical and hovering flight. So wing tip and tail nozzles jet some compressed air for low-speed steering.

A British-built vertical flier, the *Short SC.1*, with its sleek porpoise-nosed fuselage, is perhaps the nearest approach to what the sophisticated VTOL design is going to look like. Five Rolls Royce jet engines—four mounted vertically in a central bay for vertical lift and one mounted horizontally in the tail for cruising ahead—lower the experimental craft.

After takeoff, the four vertical-lift engines incline forward to aid forward thrust. During vertical landing they tip forward to give braking thrust. All five supply bleed pressure to the jet nozzles in wing tips, nose, and tail area for hovering stability. Built by Short Bros. & Harland Ltd., the SC.1 has been tested extensively by chief pilot Tom Brooke-Smith.

The 'right' way to fly

What is flying the SC.1 like? Brooke-Smith speaking:

"Vertical takeoff is a natural and straightforward process. It feels the right way to get into the air. Far more natural than hurtling down thousands of yards of concrete at two miles per minute or more. The autostabilizer works like a charm. I can hover with ease over a sixpenny piece for as long as my fuel lasts."

The autostabilizer he refers to not only operates the air jets but also the aerodynamic surfaces. Thus control response speeds up as the craft gains forward momentum, until finally the autostabilizer and jets are turned off. At that point, the pilot takes over full control of the ship. He can override the system at any time he feels it necessary.

Complex, yes. But it's the price of new-era flying performance—the price being paid by commercial aviation too.

The new age of regular trans-Atlantic jet passenger service, begun last fall by the British Overseas Airway Corp. (BOAC), is well underway now. Soviet jetliners have been on the trans-Siberian route for some years with a top speed of 559 mph, cutting the Moscow-Peiping schedule from 30 to 11 hours. Fast jet-powered runs to Copenhagen, Stockholm, Brussels, Paris, Ankara, and other cities also have been commonplace.

Has America lagged in developing jet airliners and jet passenger service?

Chronologically yes. This country has fallen several years behind both Britain and the Soviet Union. But technically, perhaps not. R & D of today's American jet transports has been thorough. We have had military jets which could have become airliners as did Russia's. As for operating competence, nearly half of the U.S. Air Force's more than 10 million flying hours are in jet aircraft.

The commercial time lag was financially caused. Jet air service is expensive for private firms to provide. Britain's BOAC got its original *Comet* into service through the expediency of full government backing, a convenience shunned by U.S. aircraft operators and builders. Russia's state-owned air fleet is not operated for profit.

The price of speed

The largest American jet airliners cost about $5 million each. Engines alone are $100,000 apiece, the cost of an entire Douglas DC-3. A single turbojet propeller is the price of a suburban home, $23,000.

But in this era of greater ease in the air, we demand more speed—and are willing to pay for it. How can a clock-haunted businessman, earning $10 to $20 or more an hour, justify a "cheaper" 150 to 250-mph flight when he can go 400 to 700 mph?

Both turbojets and turboprops have been applied to the answering of this query. The aircraft they power only recently have gone into service or are just now beginning to fly. Some will be used for short hauls and feeder service, some for business flying. And business flying—which, for example, totaled about a million more log miles in 1958 than scheduled domestic airliners—is a considerable field today, demanding its own advanced, tailored aircraft.

Dream planes

Even as passengers revel in the smell of fresh plastic and lacquer in the latest jets and turboprops, really

continued on page 84

HIGH-LIFT, LOW-DRAG WING *of Vickers VC-10 is used (a) to carry airliner through short steep takeoffs mandatory at many of the smaller Asiatic ports it was designed to serve and (b) to work aerodynamically with the four rear-mounted Rolls Royce Conway bypass jets installed at the tail for cabin quietness. This medium-long-range transport, scheduled to fly in 1961, will exceed 600 mph and will carry more than 100 passengers.*

The RESEARCH TRENDLETTER reports—and relates—significant developments of the quarter in an attempt to point out trends that may affect your business.

1st quarter, 1959

Dear Sir:

■ One of the most industrially promising—certainly the most fantastic—trends in today's research is toward machines that actually learn.

Consider what it would mean in your business to have a computer capable of programming itself, or an automatic translator to which you could dictate in one language and see the translation written in another.

> Or automatic pilots; landing and recognition systems. A mechanical librarian to digest abstracts and locate references. Or machines that run themselves and profit by their own mistakes. . .

For years, electronic designers have developed computers that make decisions and exert control—after a human being interprets their environment for them. Now, one researcher, Dr. Frank Rosenblatt (a psychologist, by the way) at Cornell Aeronautical Labs, has introduced into a machine the third essential function of the human brain—interpretation of environment.

The result: the Perceptron, the first machine that will be capable of perceiving, recognizing, and identifying its surroundings without any human training or control. The Perceptron would literally teach itself to recognize objects the first time it encounters them. Applications: all of the "fantastic" possibilities outlined above, and more.

> (A feature article on the Perceptron, describing how it will work, what remains to be developed, and feasible applications, will appear in the next issue of I·R.)

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The trend toward better and faster electronic machines also is indicated
2 in more conventional research. A teletypewriter believed to be the fastest general-purpose message printer in communications history was announced by the Army Signal Corps and Burroughs Corp. It can type 3,000 words a minute!
Using the relatively new printing technique of electrostatic recording, the teletypewriter has no ordinary keys. Even at 750 words a minute, current operating speed, keys could barely get into the air before they'd jam. Instead, letters are shot at the paper by a bank of electrode "guns."

3 A reversible, diodeless shift register employing a single magnetic wire as the memory element is under development at Bell Labs. Shift registers, used in most computers, are temporary storage devices. They perform the same function as delay lines except that stored pulses can be shifted along at will.
The new shift register takes advantage of Bell's new "twistor" technique: a wire of magnetic material when twisted can be magnetized most easily in a spiral direction and can store pulses when subjected to a suitable magnetizing field.

In the experimental shift register, information bits are written in and slid along the wire by means of tiny solenoids, each 0.075-in. long and spaced 0.075-in. apart. These coils are wound on a ceramic tube and the magnetic wire is stretched through the tube's center. The register can store three bits per inch; calculations show it can be increased to 10.

4 Radar seems to be getting more and more powerful. Latest is a radar system that can "see" in all directions at the same time. It's comprised of a number of detectors, each with a horizontal and vertical range of about 4½ degrees. How large a sector it watches depends upon the number of detectors used.

5 A new radar antenna, an inflated fabric sphere called a Helisphere, can scan throughout a complete circle without any motion of the antenna

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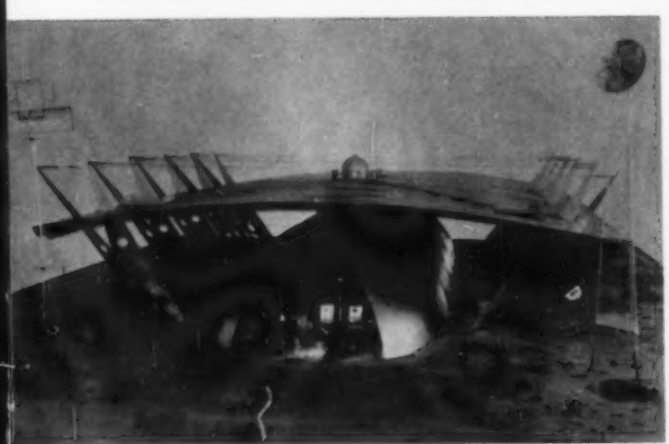

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structure. Thus it permits faster tracking than rotating antennas.

Still under development are electroluminescent phosphors to increase radar brightness significantly, and an anti-radar paint, making "painted" aircraft radar-invisible.

The paints are thick coatings of radar absorbent materials. Contents are secret, but they're believed to contain chemicals to absorb radar waves and convert their electromagnetic energy into chemical energy—much like photographic emulsions. How good are they?

The Air Force says they "greatly reduce chances of detection." If perfected, this could be the "anti-anti-missile."

And then there's this new radar speed check device that can discriminate between different automobiles in heavy traffic—developed by a British firm. Time for a new tariff?

Homes in mild climates now can be heated uniformly and cheaply with electric carpets, according to another British manufacturer.

Cost is one cent an hour.

A noteworthy trend in electronic aids to the handicapped is developing. Now that bone conduction hearing aid eyeglasses are almost commonplace, researchers have come up with a scanning device that enables the blind to "hear" books or newspapers in normal print.

The instrument interprets individual letters as musical tones, which can be memorized by the blind. After they learn to recognize the tones on a tape recording, they can learn the patterns of words and finally whole phrases. Thus, blind men actually can read ordinary printing—at a speed of from 15 to 30 words a minute.

Bell Labs is investigating the century-old technique of cathode metal sputtering for application to printed circuits. It now appears that entire circuits—including resistors, capacitors, and leads—may be laid down by this

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technique, in which ionized gas molecules bombard a cathode, dislodging atoms of metal which then redeposit on nearby surfaces.

10 A new type coiled filament has allowed Westinghouse to manufacture a smaller three-way light bulb that gives 8% more light.

11 Recent developments in thermo-compression bonding have made it possible to form large area contacts between metallic leads and semiconductor devices. Use of the technique to form contacts as much as 30 mils in diameter was reported by Bell Labs. It also is possible now to attach leads to opposite sides of a semiconductor wafer simultaneously, thus making both base and emitter contacts at once.

12 Ultrasonics now are being used by farm researchers to measure the amount of lean meat beneath the outer hide and fat of livestock. The waves return different echos when they strike a different density, such as lean meat or bone.

Similar applications have pushed ultrasonic equipment to an annual gross sale of $40 million a year. Predictions are it'll reach $150 million within five years. The increase will result mainly from greater intensities in sound made possible by transducers just now emerging from research.

Electroluminescent light—the thin panels that promise to make "picture-frame" TV possible—now are being combined with thermoelectric cells. Thus, instead of mere walls and drapes of light, you soon may be able to cool, heat, and light your office or home with single wall panels.

13 "Thermoelectricity" is a new, economical means of developing electrical energy directly from heat. Westinghouse and GE scientists are working with thermoelectric ceramics which can stand high temperatures. Previous thermoelectric research used metals (which conduct heat and electricity too well) and semiconductors (which do not work at the high temperatures of power generation).

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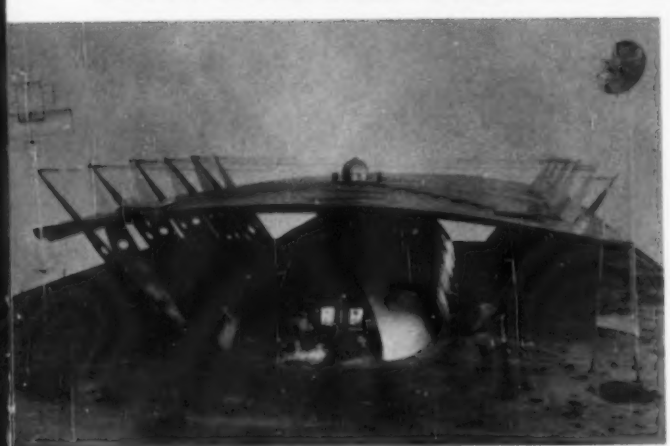

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14 Tomorrow's power: The "almost fantastic" power demands being prophesied for 20 years hence means industry will have to adopt completely new approaches according to Edwin H. Krieg, v-p of Stone & Webster Engineering Corp. Trying to do better what we already know how to do won't be sufficient to meet demand.

Generating facilities now totalling 140 million kilowatts (or about one kw per American) are expected to expand to 370 million by 1979.

16 R. G. MacDonald, v-p of West Penn Power Co., expects a million homes to be heated electrically by 1960, and 40% of all new homes by 1970.

■ There is a trend toward space travel, of course. But real space travel may not come as rapidly as so often stated by journalists and even some scientists, who should know better. Unwise predictions have had their sources in many erroneous facts, but two that have been especially prevalent are:

—A confusion of space travel with vacuum travel. Thus, although North American's X-15 is planning to fly next year in an atmosphere so tenuous that it actually is "space," its flight still is well within the gravitational pull of earth.

—A lack of realization that for every pound of man we put in orbit, it takes between 200,000 and 1,000,000 pounds to get him there and back—thereby making chemical rockets impractical if not impossible as man-carrying spaceships or satellite ships.

18 Nobel prize-winning zoologist Dr. H. J. Muller suggests using a simple device to duplicate the gravity-free state for several hours at small cost. Space scientists then could get information on effects of weightlessness long before costly direct tests of human reactions to free-fall could be carried out.

The device resembles the mechanism used for nullifying gravity in studies on plants called a "clinostat."

Human volunteers would lie down in a cylinder that would be given a moderate spinning motion about the horizontal axis. The entire body would be

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enclosed in a skintight envelope and immersed in a salt solution having the same specific gravity as the body itself.

The head?

Why that's encased in a transparent helmet.

One problem of space flight is the intense heat to which travelers may be subjected. The Air Force has discovered that men can stand the heat much better if they're pre-cooled first.

17 Aero Medical Laboratory researchers are cooling volunteers in a tank of 60° water, then popping them into a 160° chamber. Pre-cooled men can stand the searing heat for two hours—as against one hour otherwise.

18* Space-age insulating problems may be solved with a new Du Pont fibrous material that combines light weight with good heat resistance. Because of the small diameter fibers (less than 1/25,000-inch), the "fibrous potassium titanate" blocks heat penetration by scattering incoming infrared rays.

19 Liquid fluorine is the latest rocket chemical. While not a fuel, it is a fuel oxidizer, equally important to the rocket. Allied Chemical currently is supplying Bell Aircraft, North American's Rocketdyne Division, and others with the liquid for test purposes.

Westinghouse on the moon?

20 A self-sufficient solar power plant using only wire mesh and a chemically coated plastic has been proposed by Westinghouse for use on the moon.

Giant sheets of a thin plastic material would be stretched over several acres of moonland. The plastic would be coated with a special light-sensitive chemical. Then a thin wire mesh, like window screening, would be placed parallel to the plastic, but slightly away from it. As rays of the sun strike the coated sheet, the surface will emit electrons to be collected by the wire mesh.

Dr. Peter Castruccio, head of Westinghouse's new Astronautics Institute in Baltimore, feels he can get 1,200 kilowatts of d c current for every acre of

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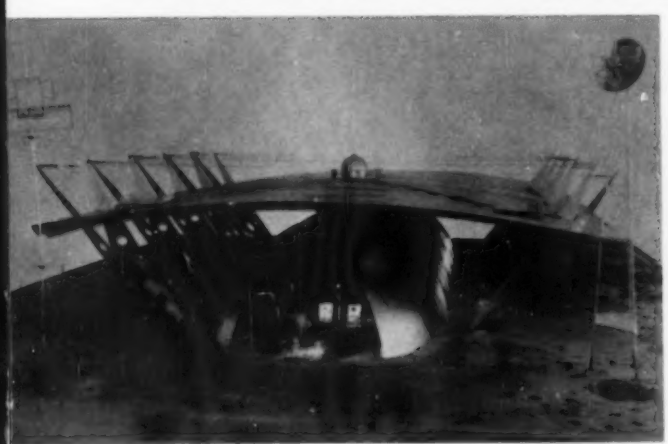

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the plastic-wire mesh surface. Total weight of required materials would be about two pounds per kilowatt, the lightest known to man.

21 A moon building has been designed for the worst conditions anticipated: a sea of dust over craters. The building would float on the dust, anchored by heavy weights attached by cables. It would be made of aluminum alloys that combine high strength, low weight, and a good reflecting surface. (Part of the problem is temperature, which varies from 214° F at midday to -243° F at lunar midnight.) The curved shield shown in photo is protection from meteorites.

22 GE's R.P. Haviland suggests sending a rocket to the sun to investigate the mysteries that affect our atmosphere. Dr. Haviland believes a solar probe could be made using available components to reach within 5 million miles of our star's surface.

23 Dr. Leo Goldberg, director of the U. of Michigan Observatory, says a payload of 300 pounds would be sufficient for satellite instruments to study the sun. He wants to put them in a pole-to-pole earth satellite that would be in continual sunshine. The satellite would be free of earth's atmosphere which absorbs much of the solar radiation.

24 A telescope on an earth satellite has long been a dream of astronomers troubled with the masking effect of earth's atmosphere. Now Dr. Fred L. Whipple, director of the Smithsonian Astrophysical Observatory, believes it can be done. The space telescope would work in connection with an electronic monitoring station on the ground.

25 If the dust blanket of meteor particles immediately above the atmosphere is as dense as 200,000 specks each cubic mile—as Dr. David E. Beard, of Lockheed Missiles, fears—it could cause pitting and erosion to the outside of a spaceship, possibly seriously impairing its performance.

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■ The 50-year-old phenol-formaldehyde has been boosted into prominence by chemical companies bent on space problems.

As a falling missile or spaceship knifes its way back through earth atmosphere, frictional heat raises the nose cone temperature to more than 10,000° F. Since metals cannot endure such heat, the problem is to develop new materials that can.

From H. I. Thompson Fiber Glass Co., Los Angeles, comes one of the more
26 promising solutions. It's a combination of silica fiber and special phenolic resin produced by Monsanto's Plastic Division.

"Low static" styrenes that can be injection-molded into products having
27 practically no attraction for dust have been developed by Monsanto. They're suggested for displays, clock housings, furniture drawers, record player arms, and other uses where smudges and dust spots are objectionable.

28 Production of the highest heat-resistant polyester plastic yet developed has begun. It's Naugatuck Chemical's Vibrin 136A. About twice as heat resistant as previous polyesters, it will withstand a sustained temperature of 500° F and a peak load of 1000° for short periods.

29 Dow reports two new plastics. One is a new elastomeric latex based on vinyltoluene and butadiene for use by the textile industry. It's suited best for upholstery and rug backing.

The other is the first expandable polystrene bead with self-extinguishing characteristics. New uses are in areas of low-temperature insulation, etc. The beads are uniform and have a wide molding range.

30 A process for laminating vinyl plastic sheet to metal on a continuous basis has been licensed by U.S. Rubber to a Japanese steel firm. Once laminated, the metal can be worked by almost any fabrication technique—including spot-welding—without damaging the plastic facing.

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■ Three recent developments point up trends in alloying and economical working of metals. Most startling is a method announced by the Air Research & Development Command for creating new alloys by "micrometeorite bombardment."

31 Example: Aluminum, which begins to boil away at 3,740° F, cannot be combined as a liquid with iridium, which doesn't melt until it reaches 4,450°. With the new technique, though, metallurgists can pulverize the iridium into tiny particles. They then can shoot them at extremely high speed into the microscopic crevices of aluminum's lattice-like structure. Thus the impossibility of mixing the two in their molten state no longer is a barrier to an alloy that will have aluminum's desirable aircraft properties, yet have a much higher melting point for space-age use.

32 Second trend is the use of explosives, sometimes in combination with simple tooling, to form difficult shapes with tough metals. The Air Force, a prime mover in encouraging the technique, says explosives are a breakthrough. "Instead of massive forming presses, we need only an explosives expert, simple tools, a tank of water, and some isolated space," says Col. P. L. Hill, of the Air Materiel Command.

Stepped-up demands for quality in high-alloy and high-purity metals have resulted in a trend toward new methods for melting them and reducing porosity.

33 One such process uses electric-arc furnaces developed at Battelle. Later improved, the furnaces now produce up to 10,000-pound ingots of titanium, high-alloy steels, and superalloys. The arc melts the metal in vacuum or inert atmosphere and the metal is allowed to freeze while still in the crucible.

34 ■ Want the strength of metal and the flexibility of rubber? A new "Flex" developed by Devcon Corp. mixes with "Plastic Steel" to produce a part that will stand up to sledge-hammer pounding without breaking.

METALS

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Plastic Steel is a filling compound that works like putty and hardens like metal.

36 Special light-weight optical glass—with a high refractive index and high dispersion—has been developed by the National Bureau of Standards. It's useful for elements of compound lenses, especially in aerial photography and periscopes where a wide field of view with minimum distortion is essential.

Usually, optical glass of high refractive index and high dispersion contains lead oxide. Trouble is that increasing the lead content increases the refractive index and limits dispersion. Instead of lead, the new glass contains sodium titanium silicate.

"Tyrex," an improved kind of rayon, is being thrown into the struggle for the $275 million-a-year tire cord market. This to counteract gains made by Du Pont's nylon in recent years.

Tyrex is marketed by American Tyrex Corp., a new firm set up by American Viscose, American Enka, Industrial Rayon, Beaunit Mills, and Courtaulds.

36 An electrical insulation material called Hot Rock permits motors and transformers to work at literally red heat. Consisting of Fiberglass impregnated with a phosphate material, Hot Rock enabled a motor to operate for several minutes at 1,200° F. One motor worked for 100 hours at 1,000°.

37 New synthetic rubber—nitrile silicone—is first to resist kerosene and other aviation fuels at a range of from minus 100° to plus 500° F. (Full feature-length story in next issue of I•R.)

■ The trend toward industrial and agricultural uses of radioisotopes continues, with the AEC now financing the search for still newer applications.

Atomic fly-killing—in reverse—is being practiced extensively in Florida. Boxes of previously irradiated, and therefore sterile, male screwworm flies are released from low-flying aircraft. The males mate

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with females, as males and females will do—but the eggs don't hatch. Isotopes in this way may completely eliminate the screwworm menace, which costs Florida some $10 million annually.

38 Two new industrial production-line units have been announced by Nuclear Corp. of America. One is an automatic device that accurately measures the contents of sealed opaque containers. It's being marketed to companies whose liquid or solid products are packed in cans, cartons, boxes, or drums. The device costs $3,000 and can gage up to 1,000 containers a minute.
The other is to make sure hidden, but vital, parts are where they should be. Applications include inspection of instruments, electronic apparatus, components—any small assembly in which the vital part cannot be seen or felt after assembly.

Since the British false alarm in controlling H-bomb power, other less-spectacular fusion progress has been reported.
Probably the most significant trend is the successful production of thermonuclear neutrons, duplicating in the laboratory the behavior of stars. Obtaining these neutrons in the plasma of deuterium gas, even for only millionths of a second, brought fusion research a step closer toward limitless cheap power.

39 Actually using the "H" or "A" bombs themselves for useful purposes is being researched. Plans already have been made to A-bomb out a harbor in northwest Alaska in 1960. The absence of a harbor on the 49th state's northwest coast has hampered development of huge mineral reserves for years.

40 A house with compressible walls that roll with the punch of an atomic blast (though not a direct hit) was developed some time ago.
Trouble is, surveys have shown "no public interest at all" in such protection. Result: Structural Clay Products Institute, which financed the research, is promoting the building for construction in hurricane and tornado areas.

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■ The trend in engines is toward smaller, "packaged," or more powerful units for airplanes, missiles, and boats.

41 A new turbo-prop engine has been developed to fit into existing American two-engine airplanes, and allow departures every 20 minutes. The director of Napier Engines Co., England, which announced the new engine, foresees elimination of costly ticketing and baggage-handling procedures—taking full advantage of the higher payloads possible with turbo-props.

Passengers would pay their fares as they board, carrying their own baggage. The airliners themselves would be weighed automatically. Savings would permit fares lower than present air-coach rates.

42 A "packaged" liquid fuel rocket—one that can be stored and used any time it's needed—has been tested successfully by Reaction Motors Division. It eliminates the long and expensive fueling process for ballistic missiles.

The Thiokol engine produces about 50,000 pounds of thrust. This is about one-fifth the thrust turned out by the Atlas, but some six times that ever obtained with a packaged liquid-fuel rocket.

43 Rocketdyne engineers this month are to begin testing an ion rocket—one that supplies thrust by emitting electrons. A preliminary engine, about the size of a two-gallon can, already has been made. It generates about 1/3-pound of thrust.

44 Chemists now believe that up to twice the power currently developed by automobile and diesel engines could be provided by nitroparaffins. Hot-rodders notwithstanding, the first investigation of the nitroparaffins as fuel is being undertaken at the University of California.

They offer an improvement because of their ability to carry part of the oxygen from their own constituents into the process of combustion.

46 Air is replacing oil for the lubrication of bearings in some machines.

By floating bearings on a thin layer of air or other gasses instead of on a film of oil, North American Aviation engineers have been able to eliminate much

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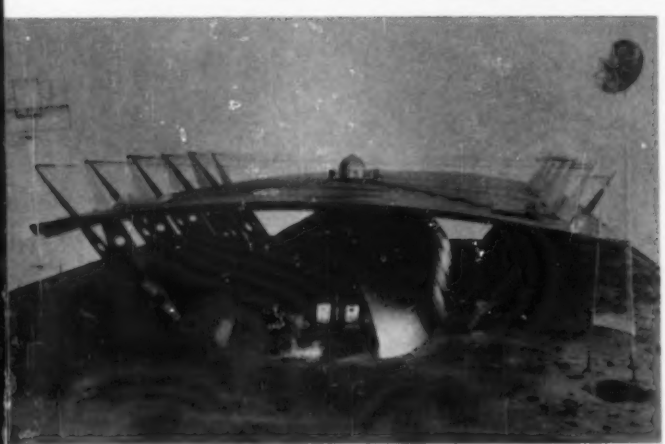

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cleaning and maintenance.

46 Development of the first antifreeze for use in ebullient cooling has been announced by Dow.

In an ebullient cooling system, circulation doesn't start until the coolant reaches the boiling point. Circulation is by natural convection. Advantages are faster engine warm-up, elimination of water pump, reduction of corrosion.

Disadvantage 'till now: vapors produced by the boiling coolant would freeze in wintertime.

■ Smaller and smaller is the trend for TV sets, components, and even tubing.

47 A tiny television set the size of a toaster has been developed by GE. The transistorized set weighs 10 pounds, has an eight-inch picture tube (diagonally measured), and isn't for sale—yet.

Monsanto now produces microtubing the size of a human hair.

48° The tubing is so flexible it can be tied in knots, is resistant to high temperatures, inert to chemicals, and is a nonconductor of electricity.

Applications include microbalances (for accurate measurement to one-three-billionths of an ounce, and recovery of helium now being lost in natural gas.

49 ■ A revolutionary ship propeller has been developed that compares in importance to the application of jet propulsion for aircraft. Hydrofoil cross-sections used in the propeller design allow fast and efficient propulsion

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through the water—something formerly impossible.

Called a "super-cavitating" propeller, it has squared ends. Previously, cavitation (for formation of a vacuum around speeding props) has been a barrier to increasing speed. But when the vacuum becomes greater than the width of the propeller, super-cavitation—and high speed possibilities exist.

Navy officials view hydrofoil craft as the coming thing. They say a 150-ton hydrofoil ship could be built with existing knowledge and equipment. Rear Adm. Denys Knoll foresees "staggering possibilities" in combining hydrofoil craft and atomic energy.

The new polar route to the Orient should result in faster construction not only of the U.S. atomic sub fleet, but also of Italian, Japanese, Swedish, and British nuclear oil tankers.

50 American Machine and Foundry is to help build a cargo sub for Mitchell Engineering Ltd., a London firm. The 80,000-ton submarine would be able to make substantial savings because of the shorter route and because atomic subs can go much faster than conventional underwater craft—with little extra fuel consumption.

51 Possibility of a nuclear surface tanker is getting the Maritime Administration excited. Cargo could be used for shielding. An R&D program now is underway to utilize a gas-cooled, closed-cycle turbine in connection with a boiling water reactor.

If the trend toward nuclear shipping continues, atomic boats will be in competition with conventional ones before 1970.

52* Solar Aircraft Co. is demonstrating a new high-speed, gas-turbine-powered crew boat for economy in off-shore oil drilling. Advantages: one-sixth the weight of comparable diesels; no engine vibration due to the rotating operation of the turbines; it will run on diesel oil, gasoline, jet fuel, kerosene, or natural gas.

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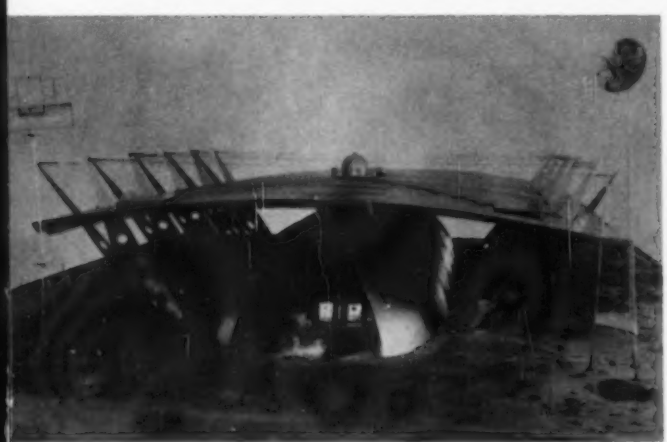

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83 Ever wonder what's three miles under the ocean floor? The Moho Committee of the American Miscelleneous Society did—and now plans to find out.

The idea is to drill down through all the layers of sediment covering the ocean floor to get a history of the earth from its very beginning. With $30,000 of National Science Foundation funds, the drilling probably will be just northwest of Cuba.

Samples from such a bore hole would replace speculation with facts concerning the earth's density, composition, mineral phases, radioactivity, and age. The boundary between the earth's mantle and its surface rocks (the Mohorovicic discontinuity, or "Moho") lies some 20 miles below the surface of continents, but only a few miles beneath the ocean bottom.

■ Identification of several new viruses may help cure the common cold. Thought responsible for many of the respiratory illnesses suffered by children, the newly discovered viruses can be developed into a vaccine for protection against them. The "common cold" now is thought to be at least 70 similar, but separate, diseases.

84 A British scientist reported that the common cold can be prevented. Weekly injections of a vaccine prepared from 1,120 volunteers' own nose and throat bacteria significantly reduced the number of colds. A control group not receiving the injections had five times as many colds. Other tests using oxytetracycline as tablets had similar results.

85 A telephone with a built-in sanitizing system that kills bacteria, molds, and virus within seconds after the mouthpiece is returned to its rest position has been developed.

86 A "jet-propelled" injector has been developed to fire vaccine through your skin without puncturing it. It's said to be safer than the needle, painless, and faster for mass injections. Now, 1,200 soldiers can be "shot" with one injector in an hour.

H E A L T H

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The trend in teeth-rotting candy and chewing gum is to make them less so. University of Wisconsin researchers have found that if as little as ½% of your diet contains oat hull extracts, tooth decay could be cut in half. Confectionary manufacturers take note.

57

■ The trend in managing industrial research is toward researching research. Now comes Case Institute of Technology with a formula for firms to use as a guide to how much money should be spent on R&D to get the greatest profits. The formula is to be wrapped up into a manual later this year.

58

Battelle has produced an inside-out world. It's a 20-foot-high concave globe showing the northern hemisphere from 20 degrees north latitude to the Pole.

59*

The map avoids the distortions of flat maps and—unlike ordinary convex globes—permits many viewers to see all of the map without moving. The photo shown is a model of the big map that will fill one side of a special Air Force viewing room equipped with 20 desks set in four terraced rows. Now they're working on a projector to superimpose bases, movements, weather conditions, etc. on the map.

For about $30 an ounce, you can get special rare-earth "paints" to measure pressures ranging all the way from tons to flea steps. Changing pressure changes the electrical resistance of the paint film, permitting easy movement.

60

A five-pound magnetic "handle" capable of lifting more than 300 pounds is for sale—for about $40. Lifting force is achieved by combining Indox magnets and polyester plastic which has a high adhesion quality to metal.

61

A new concrete building material called Calsi-Crete can be sawed, chopped, and chiseled without losing its strength. Weight is one-third of conventional concrete. It's made by blasting air through a wet mixture of

62

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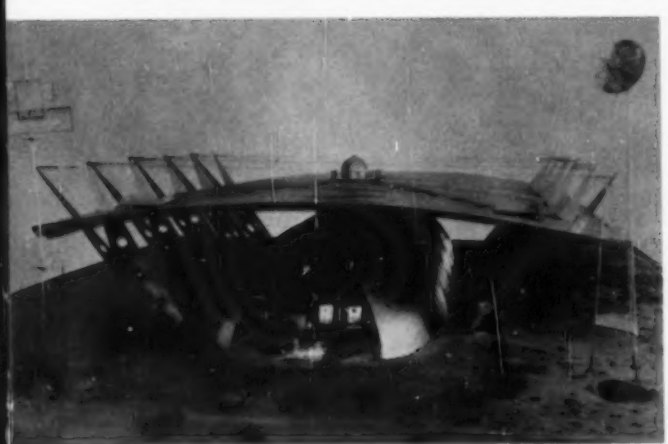

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concrete, silica, wood, and asbestos fibers. The stuff "rises" like bread, and is molded, baked, sawed to size, and polished!

A trend toward using pipelines for transporting solid particles mixed with air or water is in evidence. Most frequent items however are coal, grain, sand, salad dressing, cement, cinders, and chemicals. No "elegant, theoretical" solutions are necessary for pneumatic transport. Just good engineering.

Sincerely,

INDUSTRIAL RESEARCH

Neil Regis

editor and publisher

P.S.—If you would like additional information on any of the developments described in this Trendletter, please write directly to the organizations listed on the next page.

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2 *300 words a minute*

38 *measuring sealed packages with nucleonics*

1 Cornell Aeronautical Lab., Buffalo 21, N.Y. 2 Office of Chief Signal Ofcr., Dept. of Army, Rm. 2C-252, Pentagon, Wash. 25, D.C. 3 Bell Tel. Labs., 463 West St. New York 14. 4 W.C. Davis, Boeing Air-Plane Co., Seattle. 5 Westinghouse Labs. Pittsburgh. 6 Wright Air Dev. Cmnd., Dayton, O. 7 Thermalay Ltd., Halifax, Eng. 8 Battelle Mem. Inst., 505 King Av. Columbus 1, O. 9 H. Bassechès, Bell Labs. 10 Lamp Div., Westinghouse, Bloomfield, N.J. 11 Bell Labs. 12 R.L. Hiner, Dept. of Agriculture Exp. Stn., Beltsville, Md. 13 V.C. Wilson, Gen. Electric Res. Lab., Schenectady, N.Y.; Westinghouse, Pittsburgh. 14 Stone & Webster, 90 Broad St., New York 4. 15 Bituminous Coal Res., 121 Meyran Av. at Forbes, Pittsburgh 13. 16 H.J. Muller, Indiana U., Bloomington, Ind. 17 P.Webb, Wright Air Dev. Cmnd., Dayton, O. 18 J. B. Sutton, DuPont, Wilmington 98, Del. 19 Allied Chem. Corp., Metropolis, Ill. 20 Astronautics Inst., Baltimore, Md. 21 Wonder Bldg. Corp. of Amer., 30 N. LaSalle St., Chicago 2. 22 Missile & Ordnance Dept., Gen. Electric, Philadelphia. 23 U. of Michigan Observatory, Ann Arbor, Mich. 24 F.L. Whipple, Harvard U., Cambridge, Mass. 25 Lockheed Missile Sys. Div., Palo Alto, Calif. 26-27 Plastics Div., Monsanto Chem. Co., Springfield, Mass. 28 Naugatuck Chem. Div., U.S. Rubber, 1230 Av. of the Americas, New York 20. 29 Dow Chem. Co., Midland, Mich. 30 U. S. Rubber. 31-32 Air Res. & Dev. Cmnd., Dayton, O. 33 Battelle Mem. Inst., 505 King Av., Columbus 1, O. 34 Devcon Corp. Danvers, Mass. 35 Nat. Bur. of Standards, Wash. 25, D.C. 36 Westinghouse Res. Labs., Pittsburgh. 37 Gen. Electric Res. Lab., Schenectady, N.Y. 38 Chas. Mathieu & Co., 509 Madison Av., New York 22. 39 Atomic Energy Com., Wash., D.C. 40 Structural Clay Prod. Inst., Wash. D. C. 41 Napier Engines Co. of English Electric Co., London. 42 Reaction Motors Div. of Thiokol Chem. Co., Denville, N.J. 43 Rocketdyne Div. of North Amer. Aviation Inc., Canoga Park, Calif. 44 U. of Calif., Berkeley, Calif. 45 M. Wildmann, Autonetics Div., North Amer. Aviation Inc., Los Angeles. 46 Dow Chem. Co., Midland, Mich. 47 Gen. Electric Res. Lab., Schenectady, N.Y. 48 Monsanto Chem. Co., St. Louis 24, Mo. 49 M.P. Tulin, U.S. Office of Naval Res., Branch Office, London Eng. 50 Amer. Machine & Foundry Co., 261 Madison Av., New York 16. 51 Advanced Studies Section, Bur. of Ships, Dept. of Navy, Wash. 25, D.C. 52 Solar Aircraft Co., 2200 Pacific Hwy., San Diego 12, Calif. 53 Nat. Sci. Fndn., Wash. 25, D.C. 54 J.M. Ritchie, Pub. Health Lab., Birkenhead, Eng. 55 Lamp Div., Westinghouse, Bloomfield, N.J. 56 Walter Reed Hosp., Wash., D.C. 57 P.H. Phillips, U. of Wisconsin, Madison, Wisc. 58 Case Inst. of Tech., Univ. Circle, Cleveland 6, O. 59 Battelle Mem. Inst., 505 King Av., Columbus 1, O. 60 Stoetzel & Assoc., 307 N. Michigan Av., Chicago 1. 61 Smith's Magnet Sales Co., Whittier, Calif. 62 Continental Materials Corp., 4401 W. North Av., Chicago 39.

i n d u s t r i a l

RESEARCH

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48 *hair-size microtubing*

55

'CARRIER' PIGEON *in front of Chicago post office symbolizes archaic mail methods of the current U. S. system.*

LETTERS *still are handled manually in U. S. post offices despite availability of electronic and mechanical automatic mail sorters. Battery of postal clerks, ranging down* alley *of one of building's 40-odd primary separation cases, makes first mail breakdown.*

WHY isn't the

An old picture in the postmaster's office at New York City shows postal clerks sorting mail a hundred years ago. Except for the frock coats, this scene looks just like the one above, taken last month by an *I • R* photographer.

Since Benjamin Franklin's day, the American postal service has hand-pushed, hand-lifted, and hand-sorted mail in buildings that usually are more ornamental than functional.

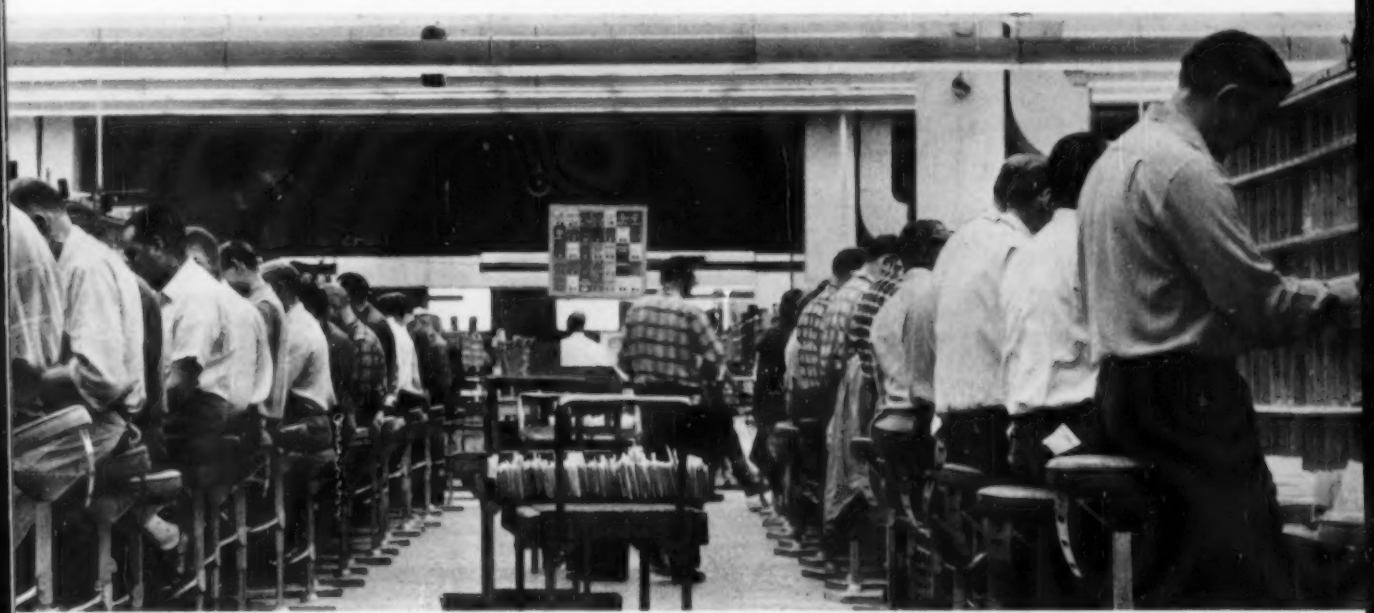
Why so backward?

There is no single, pat answer. Unquestionably, the answer includes a variety of factors, such as inertia and satisfaction with things the old way. But there also are other, more important, reasons:

■ First, not until recent years has the postal service really gotten a taste of the vast problems of delivering rapidly increasing quantities of mail. Not until 1953 was there clear recognition that the postal service must

The recent postal increases have led many industrial executives to ask the question posed below. Here, a postal official reviews several plans of post office automation, describes various automatic machines now under development, and compares the present American system with those of other advanced countries.

by Edson O. Sessions, DEPUTY POSTMASTER GENERAL



post office automated?

automate, or face a complete breakdown.

Letters: by the billions

At the turn of this century, the postal service carried a "mere" 7 billion pieces of mail annually. Even in the years just before World War II the volume was only about 30 billion. Since then, however, U. S. mail volume has doubled (spurred by such factors as increasing population, literacy, and prosperity) to more than 60 billion pieces.

A torrent of 61 billion pieces of mail per year already is descending on the nation's post offices. To give a comparison of the enormity of this mail load, if someone had been able to start counting before Columbus discovered America, and if he were still counting 24 hours a day, seven days a week, he still would not have counted to 61 billion.

The Post Office has been advised by responsible government sources that there may not even be enough

POSTAL HANDLING PROCESS, *according to latest American methods, begins as unsorted mail, dumped off conveyor belts, is gravity-fed to pick-up tables where it is rough-sorted and cancelled by postmarking equipment.*

people in the American labor market a generation or so from now to handle the mail manually.

■ Second, the needs of the U. S. postal service are unique, and unusual difficulties have prevented development of machinery that could be applied for the handling of vast quantities of mail.

The principal difficulty is that there is very little product control. It is not known from one day to the next what the "product" will be.

The nation's wastebasket

The torrent of "raw" mail dropped daily in the nation's mailboxes includes almost everything — letters, parcels, circulars, hotel keys, wallets, baby chickens, and occasionally even the family kitten "mailed" by some toddler.

About 75% of the mail comes in at the end of the business day. It floods crowded workroom floors and further crowds work areas already jammed with the evening shift of employes.

If you have never been in a big city post office workroom at rush hour, the resulting turmoil is difficult to picture. Imagine your own office suddenly deluged with millions of pieces of all kinds of mail that must be unscrambled, poked into thousands of slots, and then moved out in neat packages and bags to hundreds of destinations within a few hours.

Understand, too, that your employes would be doing almost all of this by hand, or with primitive equipment originated 30, 50, or even 100 years ago. Your basic task—poking letters into pigeon holes—dates back to Benjamin Franklin and the Colonial Post Office.

Obviously, your first job simply would be removing yourself and your people from under this huge load. To do this, you would have to develop an orderly way to get the mail to points where manageable quantities of it could be handled and sorted in an orderly way.

Mail Flo: first step

One obvious answer to the problem is conveyor belts. The Post Office Department has started to use modern conveyor systems to get its people out from under the huge load of mail that comes into some of its biggest post offices.

Called the "Mail Flo" system, it moves mail expeditiously on post office workrooms with the least amount of time and effort. The first Mail Flo, installed in December, 1956 in Detroit, is a large electronically-controlled system to move trayed mail to and from the various sorting areas on the workroom floor. It eliminates pushing mail from one work area to another, and clears workroom floors of the antiquated equipment used to push, pull, lift, carry, sort, and store mail.

Mail must be given more than one sorting. For example, it may be sorted first to a state, and then to a city within that state. Consequently, the Mail Flo system moves mail between what we call primary and secondary sorting areas.

Side conveyors feed mail to the sorting clerks in these areas and then take the letters, after they are completely sorted, to points where they will be dispatched.

Nine Mail Flo installations were announced in late 1958 for major postal facilities in New York, Boston, Washington, Chicago, Los Angeles, and Ogden, Utah. Many others will be added within the next several years.

However, Mail Flo is a mere beginning toward long-range automation needs. Mail Flo, for example, does not solve the problem of "culling" mail, picking out letters from other pieces. Dozens of men in each post office now work on this one job alone.

After culling . . .

Once culled, letters must undergo two closely related operations, which

The stereotype of a government official burdened with bureaucracy and knowing nothing of industrial processes is quickly shattered in the case of I•R author Edson O. Sessions. Formerly president of the Sessions Engineering Co., Chicago, Sessions was brought into the Post Office Department in 1957 expressly to head the modernization program described in these pages. Sessions was president of Root-Lowell Mfg. Co, and director of Powers Regulator Co.

now are done by hand or with the aid of limited machinery. The letters must be "faced" (placed in the same position so the present canceling machines can handle them), and then canceled.

As matters stand now, after they leave the hand facing operation, letters must be taken to another point and placed in the canceling machines with the stamp face down and forward.

The drawbacks are obvious. This whole job—culling, facing, and canceling—should be wrapped up in one piece of machinery. To do this, the Post Office Department has been working with American Machine & Foundry Co. and Emerson Radio & Phonograph Corp. to develop machines that cull, face, and cancel 30,000 letters an hour in a single coordinated operation. These machines also will stack the processed letters in neat piles.

In one of these machines, a "culler" feeds letters into the canceling section of the machine with the stamp in any of the four horizontal positions—up and left, up and right, down and left, and down and right. As the letters speed by, an electronic eye "looks" at each one and activates the appropriate canceling heads that cancel 30,000 letters an hour.

Another machine works on essentially the same principles, except for a different arrangement of the dies that cancel the stamps. If the letter goes through with the stamps down, the first unit cancels it; if not, it flicks the letter over and a second bank of canceling heads will handle it.

Once canceled and stacked, letters must be sorted by high speed machines. To do this on an interim basis, the department has installed in the Washington area two proven European-made letter mail sorting machines, the "Transorma" and the "Bell." Each sorts to 300 destinations. Operators sitting at keyboards punch keys which activate a memory system. This system, in turn, directs each letter to its proper destination slot.

The Transorma and Bell machines are devices of relatively low-capacity bought to test the basic ideas of keyboard letter sorting equipment. But the ultimate goal in high speed automatic letter sorting lies beyond their present capacity.

Invisible codes

To reach this goal, invisible codes printed on letters may be feasible. Electronic eyes will "read" the address on each letter and activate the machine memory system to sort it as it goes by.

Rabinow Engineering Co., Takoma Park, Md., has developed a keyboard-operated letter sorting machine that can read coded letters and direct them to the proper destination. Other work in this field is being done by Burroughs Corp. and Pitney Bowes Inc.

Electronic reading also is underway experimentally in another direction—the reading of non-coded fully addressed mail. By skipping the coding process, this may prove to be even more advantageous for certain offices than machines that work with coded mail.

Intelligent Machines Research Corp., Alexandria, Va., is engaged in developing an electronic scanning model to recognize typewritten city addresses. A jury rig model now is capable of reading typed addresses, and sorting to 18 distinct destinations.

The letters are addressed in the type fonts in most general use. The machine now is being improved to read addresses that are poorly typed or in type fonts in less common use. Some day, it even may read handwritten addresses.

With the thought that such devices may be practical for applied use in some post offices before the handwriting problem is solved, the postal service is developing a pre-sorter for this machine which will sidetrack all non-readable mail, including handwritten mail, and allow only the readable mail to proceed to the electronic reader.

Confronted only with mail it can read, the electronic reader may sort as many as 15,000 letters an hour. The sidetracked non-readable mail will go to the keyboard-type semi-automatic sorter where the address can be read by human eyes.

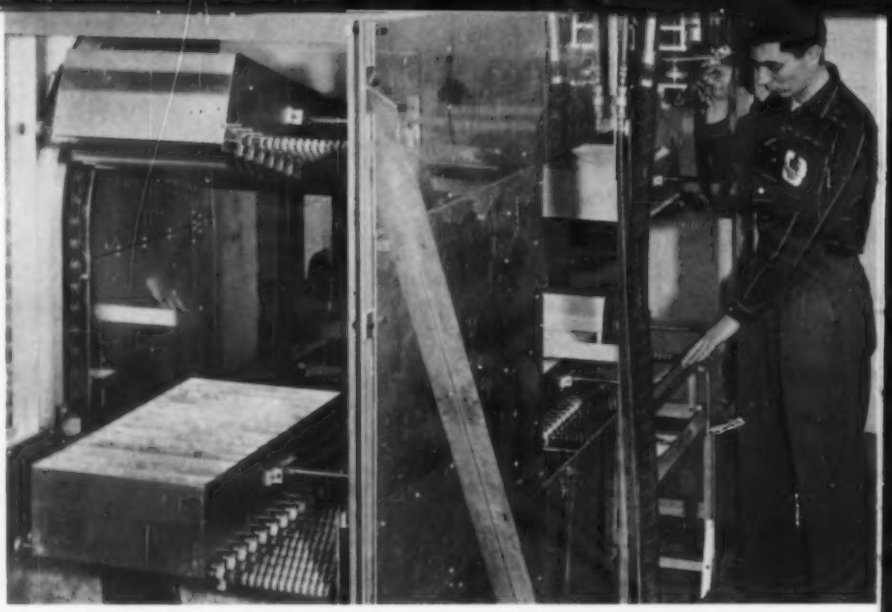
SIMPLE SOLUTIONS *are first steps to postal modernization. Sorter's stool, above, is significant because it's one of the few changes already adopted. The tilting seat cushion plus dual sets of foot rests (at base and midpoint of standard) provide a little efficiency to an inefficient operation —manual sorting. Below, a foot-pedal mailbox helps the customer.*

The parcel problem

Another major problem area is automatic parcel post sorting. Processing parcels uses 30% of post office workroom space and is a more serious problem than indicated by its billion-piece annual volume, which is about 1/60th of the total pieces handled annually.

The first semi-automatic parcel post sorter already is in use at Baltimore. Called the "Greller," it's a system of electro-mechanical controls, belts, keyboards, a memory system, diverters, slides, and working tables operated by one man who punches the appropriate key as each parcel passes him. The punched key activates a memory system which, in turn, operates paddles that push parcels off a moving belt and send them sliding down an appropriate chute for any of 21 destinations.

Experience with the Greller has shown that to increase an operator's speed, a mechanical system is needed to "face" parcels so they arrive in just the right position for easy reading of



COMPLEX SOLUTIONS *involve high-speed machine sorting. At right is a National Bureau of Standards prototype that can sort 36,000 letters per hour. Below, an optical directory converts address information into a 12-bit code corresponding to the receptacle where the letter is to be dropped by the conveyor.*

CEILING SPACE *in Chicago post office is used to advantage for parcel sorting.*

Businesses are being asked by the Post Office Department to change their mailing habits—
in the interest of having their mail delivered one day faster.
Under the new program, business mail will be picked up around noontime from specially marked boxes in downtown areas.
In this way, the PO can take advantage of its own mid-day slack time and also make better air and rail connections.
A trial in St. Louis showed the plan feasible, resulting in the promised 24-hour savings.

Meanwhile, RCA proposes a satellite postal system to speed mail between U.S. and Europe. The contents of 'space-mailed' letters would be converted electronically to microwave radio signals. The signals would be transmitted to a satellite repeating station in space at a longitude midway between the two continents. Electronic reconversion to a letter would take place on the other side and then be delivered conventionally. RCA claims cost per letter would be considerably lower than present international airplane mail.

addresses. Also the system will have to be more compressed to allow for more destination slots.

Another parcel post sorter under development by Jervis B. Webb Co., Detroit, may help meet these needs. It will position parcels and move them up to the keyboard operator. Now being placed in operation in the Washington office, the machine will sort 1,200 an hour for each operator.

An electronic memory system, activated by the keyboard, controls a pallet which will tilt and release the parcel at an appropriate chute, where it slides down to the proper point for its dispatch to destination. It will sort up to 100 different destinations.

Overhead trolley

In another somewhat related development involving handling of bulk mail such as parcel post and circulars, the postal service is installing a "power and free trolley" system in the Chicago post office to unload, store and transport incoming and outgoing sack mail.

The trolleys will utilize presently unused ceiling space and allow mail to be stored in the sequence in which it is to be processed. It will operate from an electric console control panel, and the mail will be called for and transmitted to the platform upon signaling by personnel.

In addition to these basic benefits to the post office itself, the coming automation will bring many useful innovations for the convenience of the mailer:

Tomorrow

"Around the clock" postal service will be provided by large new vending machines—about twice the size of a jukebox — and to be called the "automatic postal station." It is under development in an R & D contract with Electric Vendors Inc., Minneapolis. It will sell stamps, postcards, stamped envelopes, books of stamps, and almost all stamp items that can be bought at a conventional post office. A pilot model is expected next summer.

ANOTHER AUTOMATIC SORTER, *the Transorma, should replace manual handling. It already is under trial at post office in Silver Spring, Md. Five operators at keyboards operate Dutch-built unit, sorting about 3,000 letters an hour each into 500 separations, and combining all sorting into one electro-mechanical operation.*

The Post Office Department plans one or more experimental contracts with private firms to develop mechanized "turnkey" post offices. The contractor will have a free hand to develop a post office using all of the ingenuity and skill of American industry. Once completed, the department will turn the key, walk in with its people, and start moving the mails.

Complete modernization will make several present stations "post offices of tomorrow," such as the installations in Washington; the Terminal Annex at Los Angeles; and the General Post Office, Morgan Annex, and Grand Central Station office in New York City.

New methods in years to come will include facsimile transmission for moving some types of priority letters between post offices. (Where privacy is essential, this mail still could go by conventional methods.)

Standardization of letter and parcel sizes to adapt mail to the machines more efficiently also will become necessary, since postal machines can't be built to handle everything. For instance someone recently mailed a postcard measuring five feet long.

More types of mail may be "precanceled" to avoid the time-consuming process associated with the cancellation of the stamp. Perhaps envelopes could be sold at the post office which will be "prestamped" with invisible ink that will be recognized and handled by the machines of tomorrow.

European progress

Some of these developments, and other, more futuristic ones, such as "mail by missile," are a long way off. As far as the postal situation today is concerned, the impression has been given that the United States lags far behind some European countries. A number of articles have described in glowing terms the foreign same-day deliveries, multiple deliveries, air mail for all letters, and such gadgets as mail boxes on buses or street cars (long ago abandoned in fast-moving America).

Several deliveries a day may be very practical in a country with a few billion pieces of mail a year. In socialized foreign lands where the postal, telephone, and telegraph systems are government-owned it is feasible to have some kinds of banking and bill collecting services performed more or less directly by their postal systems.

Moreover, in some specialized areas, automation developments are ahead of ours. In the Netherlands, for example, The Hague has an automated post office already working; Belgium was to place one in operation in late 1958. Canada has automatic parcel post sorting in some offices, and is well along with experimental development of letter sorters that "read" codes, as well as machines to cull and face.

But these relatively few developments do not give a true overall picture of the United States' postal standing today. Actually we are not behind other nations to any substantial degree.

How about Russia?

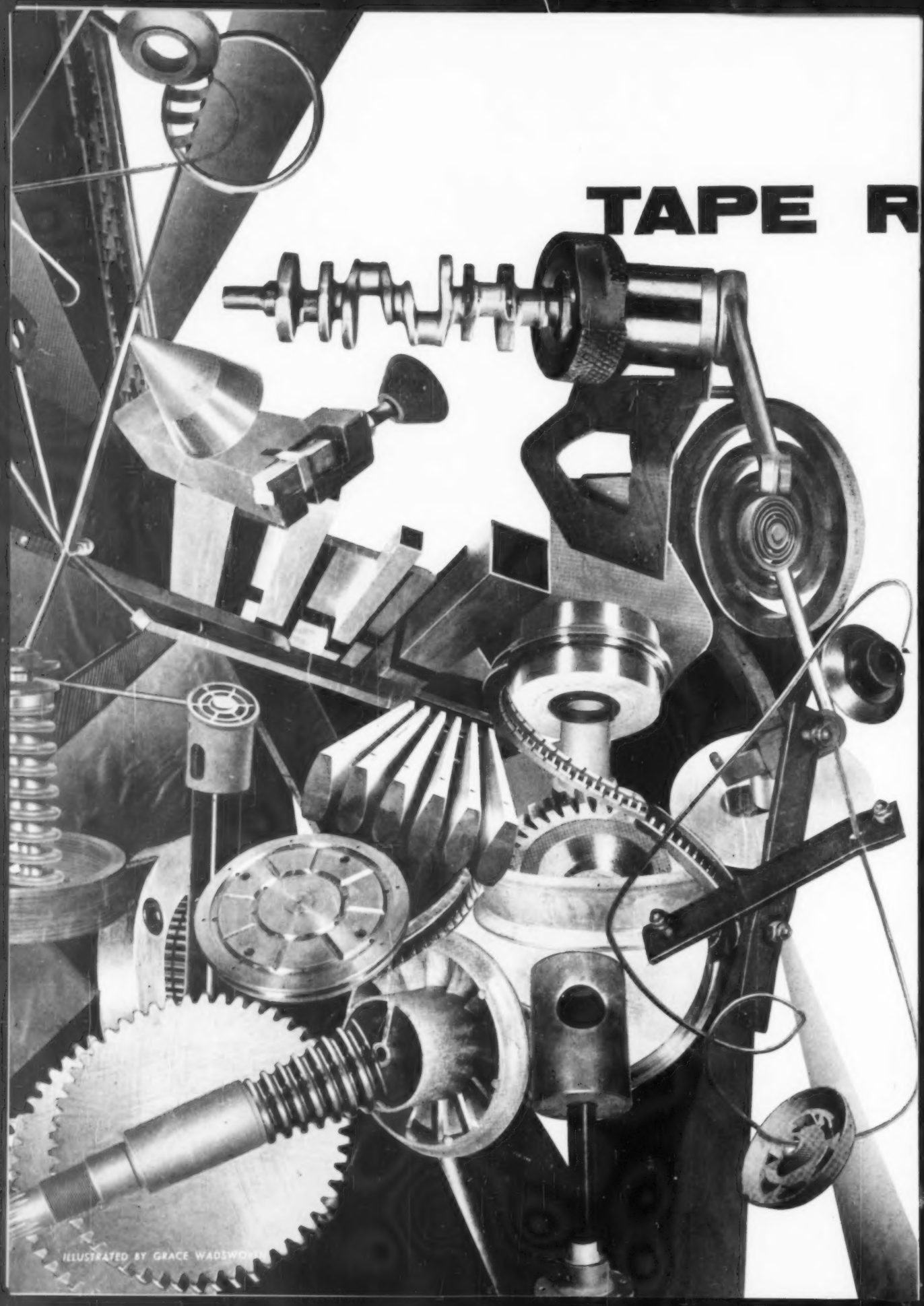
Recent first-hand experience by the author in inspecting the postal systems of Russia and other European nations indicates that we are ahead in a good many ways, particularly in the efficient, "preautomated" use of manpower.

For purposes of comparison, consider the facts that the Moscow post office handles an average of 2½ million pieces of letter mail a day. The New York post office, on the other hand, processes an average of 22 million letters a day—almost 10 times the Moscow volume.

Yet, the New York post office has a little more than 31,000 clerks and carriers on the payroll, while Moscow has 17,000 clerks and carriers—half the number to do 1/10th the job. Projecting the rate of efficiency in Moscow and the volume of mail in this country on a national scale, the U. S. would have to employ a clerk and carrier force of some 2 million instead of the 400,000 now employed.

This is not to suggest complacency. Certainly, the question "Why isn't the post office automated?" is a legitimate one—and one that can be answered best by saying, "It will be." ■

EDITOR'S NOTE: *So that we may serve you better in future issues, we'd appreciate a postcard or letter ranking your interest in this and the other articles you read. Results will appear in a "Letters to I • R" column.*


TAPE R
ILLUSTRATED BY GRACE WADSWO

Industrial applications — by **JOHN JIPP**, manager, Ampex Instrument Division

ECORDING TODAY

Today's applications of tape recording run the gamut from esoteric to ordinary: from sputnik beep-beeps to bathtubs.

Let's start with bathtubs. A new application of magnetic tape recording to the manufacture of these essential products is interesting from several standpoints. First, it points up the fact that magnetic tape is becoming industrially commonplace.

Second, the principles it puts to work can suggest literally dozens of new, similar uses for tape.

And third, the actual mechanics of the operation, though simple, are fascinating.

If you've ever tried to paint anything with a spray-gun, you know it's more art than science, and far from being as easy as it looks. Imagine, then, trying to spray the inside surfaces of a bathtub. This is how the porcelain enamel coating is applied, prior to being fired. Every square inch must be covered smoothly and uniformly. Ripples, thin spots and ridges won't pass inspection—particularly on the bottom.

Tape-gun Gauguin

Unless you discover you're a spray-gun Gauguin, you'll probably never be as good as the skilled craftsman whose everyday job it is to spray coatings on bathtubs. For it does take a knack; the motions, if you analyze them, are quite complex. Watching the professional spray-painter at work, you might conclude that his job is one in which the techniques of automation wouldn't offer much promise.

But John Coolidge, at the Borg-Warner plant in Des Plaines, Ill., concluded otherwise. He thought he saw in the potentialities of magnetic tape a way of putting bathtub-spraying and similar hard-to-handle tasks on an automated assembly-line basis. Making use of tape's ability to re-create recorded events with extreme pre-

Tape recording has come a long way from the first experimental units. Present-day assembly lines and tape-TV studios are common-place. Next stop: the automatic office, restaurant, home kitchen.

A view from the laboratory — by **MARVIN CAMRAS**
Armour Research Foundation

If a major development were demonstrated in a magnetic recorder laboratory today, you could expect five or 10 years to pass before it was in widespread commercial use. On this basis, a research scientist might do some forecasting.

However, looking back at the past decade, we realize that prophecies can be well below 100% accurate. Among the most successful advances in magnetic recording since World War II have been high frequency bias, memory drums for computers, high coercivity gamma oxide tapes, motion picture sound, stereophonic recordings, and video-tape. But other things that looked bright have not worked out, as for example contact printing of tapes.

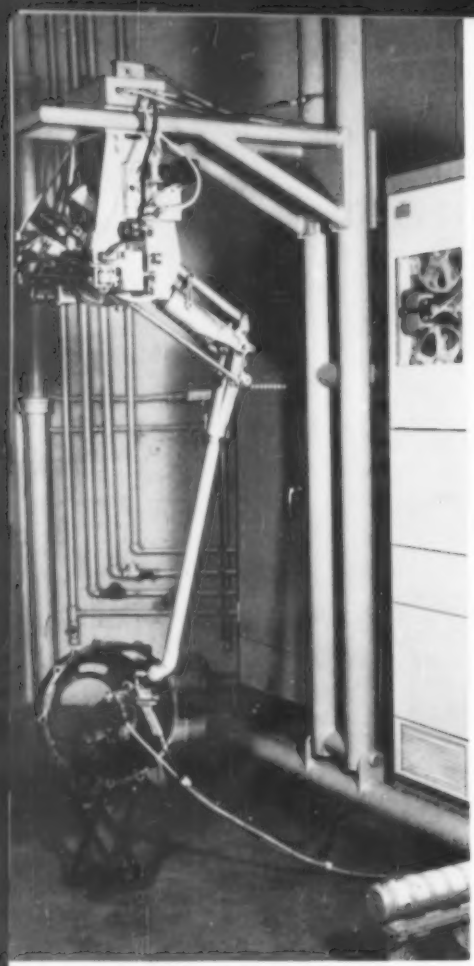
An even more classic example is the telephone answering machine, for which purpose Valdemar Poulsen is said to have invented magnetic recording in the year 1898; some 60 years later, telephone answering machines for offices are still a novelty.

So, without predicting, we will note some things presently in the research laboratories.

Picture recording on your home TV

The advent of video recording on tape, now extensively used by the major broadcasting networks, has fired the imagination of many who see it as a replacement for photographic film. A home movie camera would load with a roll of magnetic tape. Videotape does not have to be processed, and could be viewed immediately on your home color television receiver. Part or all of the tape could be erased and reused as often as desired.

All of this is still in the dream stage. Today's videotape recorders cost about $50,000, weigh a good fraction of a ton, and require specialized technicians for operation and maintenance. (These considerations detract from the appeal to most home movie makers.) Moreover, there is nothing on the horizon that seems



'BATHTUB' TECHNIQUE *devised by Borg-Warner is applied to the automatic paint-spraying of a housing.*

cision, he devised an automatic spray system which goes through all the motions, turns out perfect bathtubs every time, and can stay on the job 24 hours a day.

To watch the Borg-Warner brainchild at work is an uncanny experience. A mechanical hand grasps the spray-gun, makes a series of graceful, sweeping passes interspersed with short, deft strokes, and triggering long or short bursts as needed. Moments later, the job finished, the mechanical arm "relaxes" as the next tub moves into position. The whole operation seems to be guided by a near-human intelligence—as of course it is!

The difficulty of setting up such an operation seems insurmountable, even to a person familiar with standard programming techniques. Actually, it would be almost impossible mathematically to establish an operating cycle to coordinate the spray-gun aiming direction, path, speed, distance from target, and trigger pressure necessary to duplicate human results.

The Borg-Warner programming technique, however, was simple. Motions of the spray-gun in the hands of a professional spray-painter merely were recorded during a regular production run. Sensitive transducers at the spray-gun itself were used to pick up linear and angular motion in all three planes. Recorded on tape as exactly reproducible electrical voltages, the motion is re-created on play back.

Applying 'bathtub' technique

After you've seen the tape-controlled bathtub spray in operation, it's not difficult to come up with other applications. Imagine, instead of a spray-booth, a workbench where a skilled glass-engraver holds a crystal goblet up to a tiny copper wheel to cut beautiful three-dimensional designs into the glass. Here again there's more art than science; yet every exquisite scroll can be captured on tape, using the "bathtub technique," and re-created with all the perfection of the original.

Whether the tape-programmed operation involves operating a spray-gun, cutting tool, or punch-press, it offers other advantages in addition to that of exact reproducibility. One of the most important is that it permits the motion or operation to be duplicated simultaneously at as many as a dozen stations, thus multiplying its effectiveness as a mass-production technique.

The ability of tape to direct a multiple-station operation is put to interesting use in automotive testing by Esso Research and Engineering Co., in Linden, N. J. Here, tape programming is used in the laboratory to eliminate the "human-factor" variation in testing fuels and lubricants.

Esso used to operate a fleet of cars on the open road for this testing. Each automobile was driven by a man selected for his ability to perform as an "average" driver. Even so, test re-

likely to reduce such limitations by the required factor of about 1,000.

Extensive research has been done in video recording by RCA, General Electric Co., Ampex, Crosby Enterprises (now Mincom Division of Minnesota Mining & Manufacturing Co.), Armour Research Foundation, and others. The most successful video-recorder to date is the Ampex, which uses high-speed rotating heads for lateral scanning of a two-inch wide tape travelling at 15 inches per second.

RCA has demonstrated machines which use narrower tape travelling about 240 inches per second. A third method, which multiplexes the video information on about 10 parallel channels, has proved rather tricky to operate. Other approaches show promise, but aren't ready yet for public demonstration.

Though important advances now are predicted, the photographic film industry shows no worry about its immediate future.

Magazine loading eliminates threading

"Tape recording" implies a roll of tape as the record member. The operation of threading a roll of tape onto a recorder is more difficult than putting a record on a phonograph. The obvious remedy for this inconvenience is to enclose the spools in a cartridge or magazine which can be inserted into the machine without threading.

Magazines for specialized uses were available for many years on machines made by Peirce Dictation Systems, Mohawk Business Machines, Dictaphone, Permoflux, and others. Invariably they have been too expensive and too bulky for the ordinary tape recorder.

Some time ago, the Cousino Co. announced a cartridge that was nearly as compact as a roll of tape. In the Cousino cartridge, tape in an endless loop is pulled out from the inner core and winds up on the outer layer. When the record has played through, it's back at the beginning ready for another cycle without rewinding.

This feature is ideal for pre-recorded music, but on a general purpose machine it has a major disadvantage: the tape cannot be rewound, but must be played entirely through before you can listen to a short recording you've just made. Reeling of the tape is quite critical, since each turn of tape must slide freely and continuously against the adjacent turns as these travel from the top layer to the bottom layer of the winding.

Another form of magazine, developed by RCA, is generally comparable to the movie film magazine of

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sults often were inconsistent and inconclusive.

The only 'average' driver is a tape recorder

Esso discovered there's no such thing as an "average" driver. For example, one test driver was found to be consuming an extraordinary large amount of gasoline, for reasons not immediately apparent. It was discovered eventually that, while enjoying rock-and-roll music on the car's radio, the driver unconsciously kept time with his foot on the accelerator! Under orders to leave the radio turned off, his gas mileage improved.

By eliminating nearly all the human factors, Esso recently has upgraded its test results and canceled out many inconsistencies. Though the same test cars are still put through much the same paces as before, they're now all driven by magnetic tape. Instead of attempting to produce consistent results by repetitive test drives over predetermined courses on street and highway, the cars now are operated on tape-controlled "treadmills" which duplicate actual road conditions as recorded during a previous, carefully controlled test drive.

When the test automobiles go on a "trip," all are subjected to the speed changes, acceleration, braking action, idling, inertial forces, and even wind effects they would encounter on an actual drive. Since the treadmill subjects all cars to precisely identical forces, simultaneously, the testing is more efficient and the results far more meaningful.

A similar testing procedure, used by Timken Axle Co., duplicates rough road conditions on tape in the laboratory to determine the strength and life expectancy of various axle designs. To put a rough ride on tape, a number of strain-gage transducers are attached at various points of stress on the axle of a test vehicle. Then, as the vehicle is driven over various types of terrain, the output of each transducer is recorded on separate channels of a single magnetic tape.

Back in the laboratory, electrical signals on the tape drive a dynamometer and loading devices which can subject a test axle to exactly the same stresses and strains encountered by the axle on the original test vehicle.

Humanless milling

Another tape-programming application—one which is achieving big savings of both time and money for many large manufacturers such as Convair, Rohr Aircraft, Lockheed, and Martin—is the tape-controlled milling machine. This remarkable device permits the machining of intricate parts without a human operator.

The machining of parts on the tape-controlled mill, sometimes called a numerically-controlled multiple-axis profiler, can be programmed directly from the blueprint without the need

DRIVERLESS TEST CARS *are run on a tape-controlled treadmill at Esso Research & Engineering Co., Linden, N. J. Acceleration, speed, and braking patterns of an actual auto trip, previously recorded, are duplicated exactly using tape.*

Eastman Kodak. The tape magazine is rectangular, measures 7¼ x 5 x ½ inches, and contains two hubs side by side, holding up to two hours of recording on extra thin tape at 3.75 inches per second. Four tracks are used either singly in succession, or as pairs for stereophonic sound.

Vast fidelity at 2″ per second

If we could record twice as many wavelengths per inch of tape, then we could run at half the speed for the same performance in regards to frequency response. In earliest recorders, speeds of 100 inches per second were required for audio. Now we can obtain vastly superior fidelity at less than two inches per second. The improvement is a result of higher *information density*. In other words, we can record more wavelengths on a two-inch length of tape now, than we could formerly on 100 inches of inferior material.

While higher information density is a convenience for audio, it is an absolute necessity for video, because video information comes through about a thousand times as fast as audio. One of the major problems of video is to increase the number of wavelengths that can be recorded per square inch of tape. The same is true in the fast-growing field of data recording, where information density is expressed in bits, or pulses per inch or per square inch.

The race for higher information density demands better recording and playback heads, vastly improved tapes, and more precise mechanical transport systems. Already the gaps in heads are measured in terms of wavelengths of light. Recording densities reckoned in tens of thousands of wavelengths per inch, or hundreds of thousands per square inch, have been achieved under laboratory conditions.

Whether these can be translated into commercial systems of adequate reliability and economy remain to be seen.

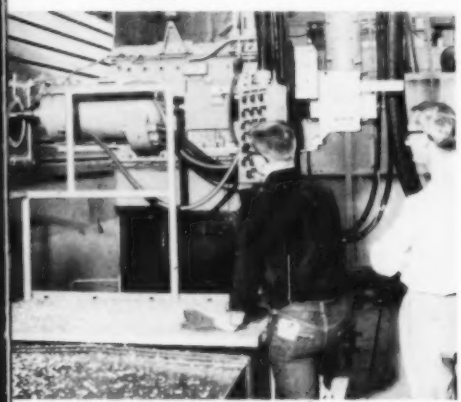
Dictation recorders: a magnetic future

Magnetic recording has such unique advantages for dictation use that this was one of its earliest applications. Because magnetic records can be erased and used over and over again indefinitely, the cost of supplies is negligible. Moreover, a person can correct his dictation by erasing a word, a sentence, or a paragraph; and then re-recording.

Dictation imposes specialized requirements such as rapid and accurate indexing, start, stop, backspace, playback of the last phrase during dictation, etc. To

for models, templates, or special jigs. Lead time between drawing board and finished piece often is reduced by as much as two thirds. Set-up time is minimized, tolerances are improved, and chances of human error are virtually eliminated.

In operation, the milling machine's cutting tool is positioned along its three coordinates by electrical impulses recorded on the program tape. The cutting tool receives as many as 200 commands a second, each one defining an exact position for the tool (correcting for tool wear at the same time) and enabling it to remove metal from the work piece to tolerances on the order of one ten-thousandths of an inch.



CHIPS FLY *as a "taped" profiler shapes a complex airplane part at Rohr Aircraft Corporation's factory.*

The automatic office

Magnetic tape recording today is playing a significant part in the development not only of the automatic factory, but of the automatic office as well. Digital recorders, using binary coding to store as many as 4800 bits of information per square inch of tape, are used increasingly to feed information into and out of computers and other electronic office machines.

A single standard reel of magnetic tape can hold more names and addresses than there are in a 1,000-page telephone directory. In about the same length of time it might take you to look up a person's name and number in the phone book, a modern computer with magnetic tape input/output can search the entire book by means of the *number* and come up with the *name*.

Among those using taped computers to post payroll and inventory information are the Bank of America, the Marine Corps, and Johnson's Wax Co.

When coupled with a newly developed high-speed printing device, magnetic tape can give up its recorded information in the form of printed copy at the rate of nearly 5,000 lines a minute. At this rate, for instance, it can print more than two million magazine mailing labels in an eight-hour day.

One of tape's most spectacular abilities, and one of the best known, is video recording. Though TV recording is the most obvious and currently the most widely exploited videotape application, there are many other new and promising uses for videotape beyond entertainment.

Because videotape offers the unique ability to record information over a frequency spectrum more than four megacycles in width (broad band), it is finding application in simulation, monitoring, and the like.

Videotape 'ground-school'

For example, a videotape-programmed sequence of events can realistically simulate a jet aircraft training flight. Thus the "ground-school" student can be thrust into an array of complex situations which, under actual in-flight training conditions, might require undue risk of life and equipment. And by programming several repeaters from a single videotape instrument, any number of students can be exposed simultaneously to exactly the same training situation—thereby allowing fair comparisons.

Videotape isn't the only means of capturing visual information on magnetic tape. A new tape recorder that works in conjunction with facsimile equipment now makes it possible to record photographs, drawings, printed matter, or blueprints on magnetic tape. They can be reproduced subsequently once or thousands of times, retaining practically all their original sharpness and detail.

In operation, this tape machine records the electrical output of con-

meet these requirements and others, many approaches have been tried, including wire and tape on spools and in cartridges, belts, drums, discs, and flat sheets.

In this country every one of these designs has met with some success. Yet none has displaced the older methods which use mechanical grooves. We may speculate as to whether this has been attributable to high cost, to poor design, to unfavorable merchandising, or to pure inertia. Regardless of its present status, the entire industry feels that the future of dictation lies in magnetic recording, and major companies as well as independent laboratories are working toward a definitive design.

Magnetic memories—computers and satellites

High-speed digital computers, machine-tool control systems, and data processing machines all require a memory where information and instructions can be stored. The information almost always is coded and stored as binary digital bits or pulses, since this gives maximum economy of storage, and is in the language directly understood by the machines.

Two important requirements are apparently contradictory: **1** large storage capacity, and **2** short access time.

For large storage capacity, nothing yet has been found that excels magnetic tape wound on reels, as for example in the tape memory of the IBM Model 702 computer. Yet this is the worst possible form for rapid access to randomly selected information, because it may take a minute or more to wind a reel to the required place.

At the other extreme is the magnetic surfaced drum made by Ferranti Electric Inc., New York, which rotates at 23,500 revolutions per minute to give an access time of 2.5 milliseconds or less on any one of 20 channels. Fast as this may seem, it is thousands of times too slow for the short term memories of computers where times are reckoned in microseconds or milli-microseconds. However, the magnetic drum is widely used to complement the faster memories in data processing, since its capacity is far greater than anything attainable with faster memories.

A system that holds as much information as a roll of tape, but with greatly reduced access time has been developed by IBM for its RAMAC (Random Access Memory Accounting Machine). This is a sizable recorder with 50 discs, each two feet in diameter mounted concentrically on a shaft driven by a one-horsepower motor.

ventional facsimile equipment used by wire photo services and inter-plant communication systems. Unlike ordinary facsimile transmission, however, the taped information can be speeded up for fast transmission to other recorders at the receiving station or stations.

At the receiving end, the taped facsimile impulses are reconverted to the original photograph or drawing on a simple, direct-writing facsimile machine — without having to process photographic negatives or prints.

Fast blueprint transmission

An interesting application proposed for facsimile-on-tape involves a large corporation which has reduced its blueprint files to microfilm. By scanning a projection from the microfilm original and recording it directly on tape (without photographic processing), quick reproduction of blueprints will be possible at any one of the company's nationwide network of plants.

Magnetic tape recording techniques have been used in the long-distance transmission of almost every conceivable type of information. Last September, for an out-of-the-ordinary example, a doctor in Maryland used tape to acquire six items of medical information simultaneously from a patient in Naples, Italy. With immediate access to electrocardiogram, heart sounds, breast sounds, respiratory rate and volume, and myograms (measures of muscle activity), the doctor was able to make a complete "bedside" diagnosis from across the Atlantic Ocean.

In other medical applications, magnetic tape is used in locating brain tumors, measuring fetal heartbeat during childbirth, diagnosing early schizophrenia, measuring brain waves and nerve potentials, and in studying heart disease.

Many of the new tape recording applications have been built around the loop recorder, a tape machine which records continuously on an endless loop of tape. In the far north, this recorder is running radar warning stations on a round-the-clock schedule without human operators.

A typical industrial application employs the time-delay talents of the loop recorder. With loop length and tape speed adjusted to coincide with conveyor belt speed and distance between stations, a non-standard part passing an inspection station automatically is eliminated when it reaches the rejection station.

One of the most important and rapidly growing industrial uses of tape recording is to program the "shake-table." Rocket and missile components manufacturers, for example, tape the actual vibration environment in which a component is expected to function. The shake-table is programmed from actual missile flights.

Shaking the shake-table

At Caltech's Jet Propulsion Labs, new complex-wave vibration testing techniques have been developed for such purposes as testing the components sent aloft in the Explorer satellites. These techniques involve the use of shake-tables programmed with a composite of random noise, engine vibration, aerodynamic properties, and structural resonances. Once on tape,

continued on page 82

THE AUTHOR

Elaborating the current industrial uses of tape recording comes easy to John Jipp, manager of Ampex' Instrumentation Division. Jipp became an officer of the company in 1957 after long experience in marketing, sales (for Motorola), design engineering, and field research of military radio equipment during World War II.

Five million characters (up to 40 million bits) can be stored, which is equivalent to 60,000 punched cards, or 2,000 feet of magnetic tape.

Undoubtedly the lightest-weight magnetic memory is one built for the U. S. satellites. Information is recorded continuously during the two-hour traverse of a satellite orbit, at the same time winding a spring. When the satellite passes over a control station the spring is released and two hours of information are transmitted in seconds. The record then is erased for the next traverse.

THE AUTHOR

Your business of the future probably will be affected more by Marvin Camras' work than by your own. Certainly the present-day $100 million a year recording industry would not exist without him. Often called the "father of modern recording," quiet, unassuming Marv Camras holds practically all the basic magnetic recording patents—more than 200 of them. A senior scientist at Armour Research Foundation, Camras' inventions are used in motion pictures, radio and television, office machinery, high-speed computers, and most of the other developments described on these pages. Along with Thomas Edison, Lee DeForest, Marie Curie, and others, Camras is a winner of the coveted John Scott Award—distributed for the past 143 years "among ingenious men who make useful inventions."

The field of magnetic data storage has barely been explored. At present it can truly be said that by the time a machine is put on the market it is already obsolete.

Ferrography for facsimiles

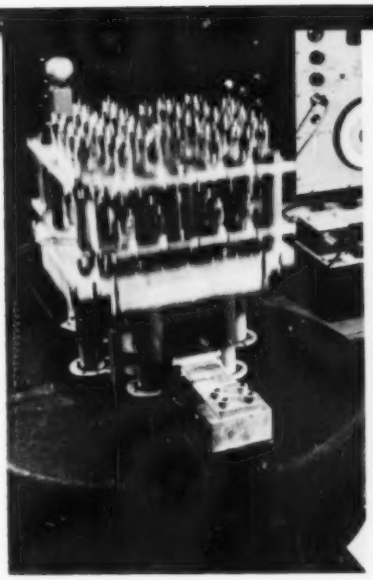
If a fine suspension of magnetic power is placed on the surface of a recorded tape, the particles will be attracted toward the regions of high magnetization, and an image will appear which shows the otherwise invisible magnetic pattern on the tape. This is ferrography.

Ferrography can be applied to facsimile, and to high-speed printing of characters. Clevite Electronic Components Co. has developed a graph recorder using this principle which operates many times faster than any pen-and-ink type recorder.

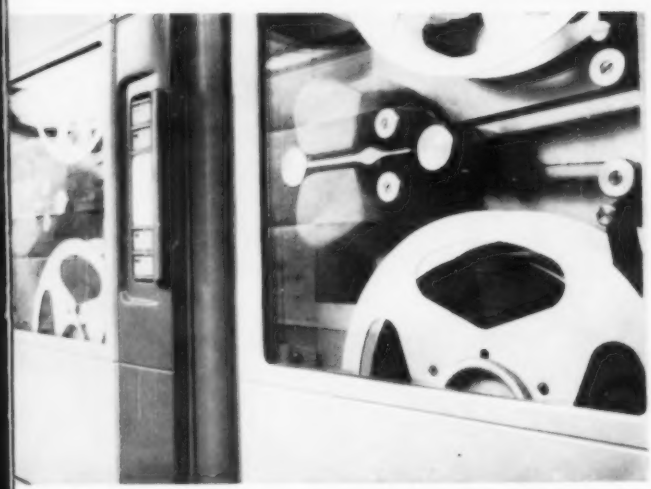
Sensitive pickup and playback heads

Nothing is as yet competitive with ordinary magnetic pickup heads that respond to rate-of-change of magnetic flux. A shortcoming of such heads is that their output drops to zero when the frequency to be picked up becomes zero (d-c magnetization).

A magnetic modulator head has been developed in which a high-frequency carrier responds to magnetiza-



'SHAKE TABLE,' *right, literally shakes a rack of electron tubes to death—to see how long it took. The shaking, on tape, is exact duplicate of a missile's flight. Below, a battery of tape recorders works aboard U.S.S. Mariposa, where Bell Aircraft studies ship motion.*



tion of the tape. The modulator head is sensitive even when the tape is not moving. Not only is this head ideal for special applications, but its high-frequency output is enough to energize an antenna. Tapes which are played back can be picked up with an ordinary broadcast receiver, without any additional amplification.

Playback heads also have been made where magnetization of the tape deflects an electron beam in a cathode ray tube. Such heads have characteristics which, like the magnetic modulator head, enable them to sense frequencies down to zero. Their main disadvantages are large size which makes them clumsy and difficult to shield, lack of stability, and life limited by filament burnout.

Semiconductors have been used successfully for active elements in pickup heads. Heads utilizing the Hall-effect, the magneto-resistive effect, or even magnetic effects on transistor action have been proposed. As new semiconductors of superior properties become available, it seems reasonable that they will be used widely in magnetic recording.

In summary, magnetic recording today has dozens of new avenues that have barely been explored—this in contrast to 15 years ago when many considered it "solved" except for the finishing touches. ■

How did Ben Franklin make so much money?

By being a scientist? A diplomat . . . executive . . . inventor?

By all of these things: by avoiding the popular "science" of the 1700s (witchcraft) and by enlisting experimental methods for useful purposes.

Or, as we'd say today: by avoiding timeworn methods and by applying the results of scientific research to industry. The Franklin stove and the lightning rod were applied research at its best.

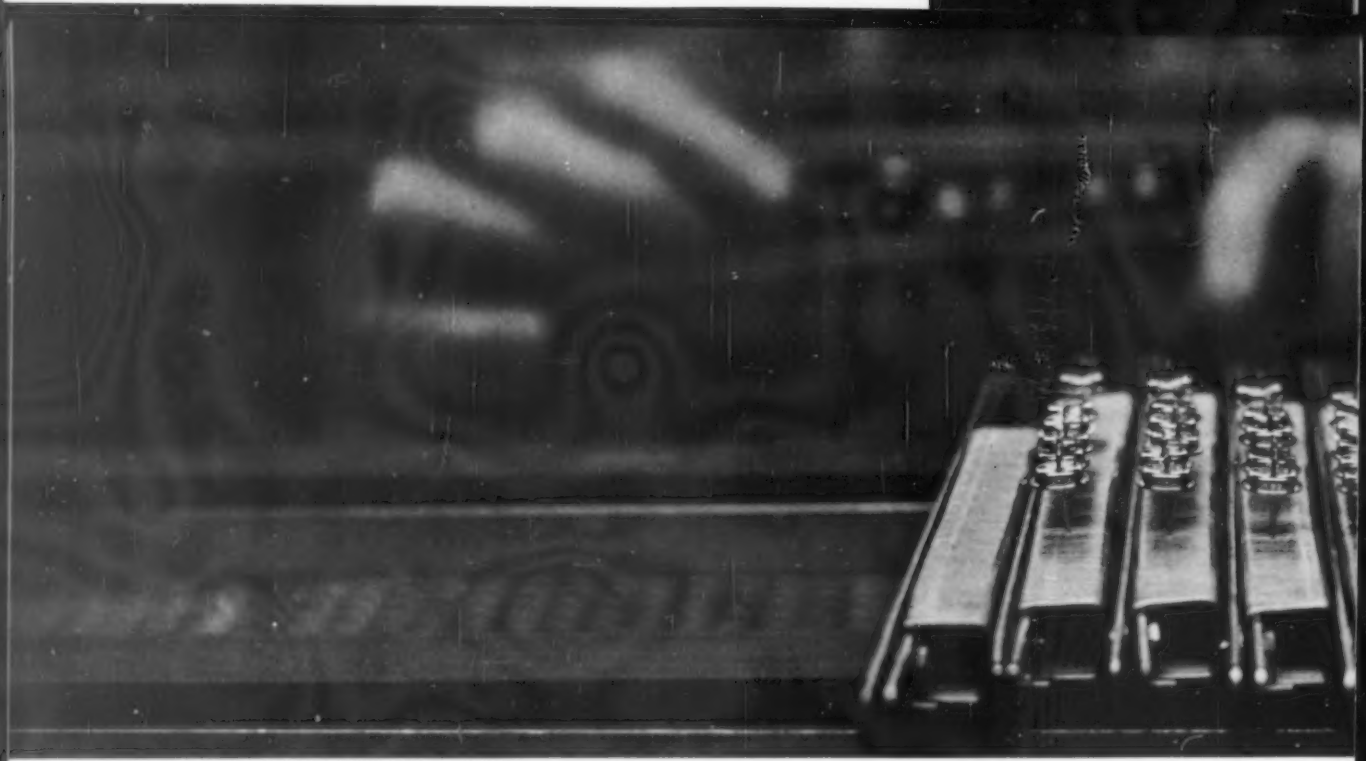
It was Dr. Franklin's insatiable curiosity that earned him his fortune. A curiosity that carried him far beyond his narrow "field," of printing, and into many other fields.

Today more than ever, industry is interrelated. Chemical management needs to know what's happening in the steel industry. Electrical executives must keep informed about aircraft, automation, atomic energy, metallurgy, space technology . . .

Filling this need to know—your management need—is the purpose of Industrial Research *magazine.*

Reading it will not put your picture on a 50-cent piece. But it may help you gather a few.

THE MANAGEMENT MAGAZINE OF TECHNICAL PROGRESS



What is the nature of the coming $500 million semiconductor market?

Why is it so certain?

What new developments can be expected to meet tomorrow's evolving technology?

semiconductors: a dynami

Continuous growth of the electronics industry depends upon developing more complex systems and then solving the acute problems arising from maintenance of such systems.

Your home TV or hi-fi set, the machine shop moving toward automation, large data processing centers, and space satellites—all have one thing in common: a compelling need for components that guarantee minimum service and minimum replacement.

Semiconductor devices are precisely suited to this technological pattern. Incomparably reliable and promising virtually infinite life, they have become so important as to form a dynamic new industry *within* a dynamic "new" industry, electronics.

GE'S *new thermionic converter —made of metal and ceramic— is the size of a quarter.*

The market

Semiconductor sales — principally the sales of diodes and transistors — have more than doubled annually during the past 10 years. Diode sales increased from less than a half million units in 1946 to 56 million units (or $73 million) in 1957. The sale of transistors, newborn in 1948, rose to 29 million units ($70 million) in 1957. Fifty-five companies sold over $200 million worth in 1958, despite a reduced growth rate early in the year. Forecasts indicate a potential $500 million market in the United States within five to 10 years.

What is the nature of this tremendous market? What properties assure the future of semiconductor devices? What new developments can be expected to meet tomorrow's evolving technology?

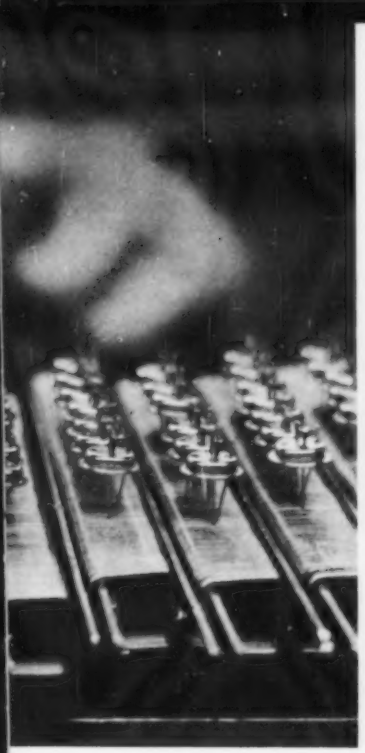
Semiconductor devices are electrical components based upon the junction properties of semiconductor materials. They are being introduced and used at an increasing rate in *every* area of the electronics industry today.

The electronics industry, only recently arrived in the fifth position among United States industries, accounted for $12 billion in sales during 1957. Growing rapidly and ever more important to each major American market — capital equipment, consumer goods, and military systems — the electronics industry itself provides an ample future market for semiconductors.

Romantic transistors

The principal semiconductor, the transistor, is young; its first commer-

by Walter F. Leverton and David Rubinfien, Raytheon Manufacturing Co.



TRANSISTOR SUBASSEMBLIES *pass in review for visual inspection before they're tested electrically and then encapsulated.*

A SINGLE CRYSTAL *rises magically out of molten germanium at Raytheon's lab. Double exposure dramatizes "growth."*

new industry

cial sale took place less than 10 years ago. Yet, this tiny device has revolutionized the electronics industry. From the moment of its announcement by Bell Telephone Laboratories, dozens of companies and thousands of scientists and engineers flocked to investigate its properties, manufacture, and application.

Few inventions in history have been surrounded by such intriguing, if not romantic, prospects. Virtually every kind of scientific and production specialist has been involved in its development: theoretical physicists, physical and organic chemists, metallurgists, plating specialists, machine designers, miniaturization experts and, of course, the users — electronic and electrical circuit and systems design engineers. Fruitful cooperative effort on the part of all these groups has resulted in the transistor's rapid development.

An amplifier, the transistor is similar in the function it performs to the vacuum tube (thermionic emission tube). But in its fundamental properties, the transistor is so different that its potential extends far beyond that which could be visualized for the vacuum tube.

No one characteristic of the transistor adequately distinguishes the device — its incredibly small physical size, light weight, low noise, reliability, almost fantastic resistance to adverse mechanical environment, unbelievably long life, or moderate cost. Rather, it is the combination of all of these characteristics in a single device, coupled with the ability to amplify electrical signals.

Since the electronics industry is concerned mainly with the processing and transmission of information, the inherently high-power efficiency of transistors at low-power levels makes them uniquely suitable in this area.

The precise energy levels required for processing information in a given system are determined by the ability of the system to discriminate between information and inherent "noise" (electrical interference) at each stage. Similarly, the transmission of information requires adequate signal-to-noise ratios and, at most, energy levels consistent with the thresholds of sensory perception where humans are involved in the system.

The transistor admirably meets each of these requirements. It is limited in practice only by the frequencies desired for the *highest* speed data processors and the *highest* frequency communications systems or by the high-power requirements of selected applications.

The efficient control of power at substantial levels, however, is within capabilities of the present transistor. Conceptually, much greater increases in handling capacity and efficiency are possible in transistor designs. Thus, completely automatic control systems directed by information developed at very low energy levels will be capable of amplifying and directly controlling vast amounts of energy.

'Unbelievable' climb

The future of semiconductor devices will encompass both new applications and more complete exploitations of existing ones. The result will be a rise in usage so steep as to seem almost unbelievable even to active participants in the industry. This prediction is predicated on three factors:

1. The applications of electronics both to military and commercial end use will continue to multiply at a rapid rate.

2. Increasing replacement of other components (vacuum tubes, gas tubes, etc.) by semiconductor devices is inevitable.

3. New semiconductor devices, as yet not out of research and development, promise to perform entirely new functions and give the equipment design engineer a new dimension in which to exercise his talents.

For the immediate future, the trends are obvious. The increasing complexity of electronic equipment has stirred up the problems of physical size and reliability. Semiconductor devices offer relief in both areas and promise even more effective solutions.

As the processes of manufacture improve to provide higher purity materials, perfectly conditioned surfaces, and more effective package seals, a new order of reliability with nearly infinite life expectancy becomes a distinct possibility for the future.

Components in a package

Somewhat primitive developments in size compression already have

PRODUCTION LINES *such as this one at Zenith, where portable radios are being assembled, use transistors by the millions.*

achieved widespread acceptance. These multiple packages consist of a number of semiconductor diodes and/or transistors, electrically connected and assembled with other miniature components to perform a given circuit function—all encapsulated as a single plug-in or solder-connect package.

This approach greatly reduces design and assembly time for circuits involving fairly standard functions. It is practical for the semiconductor manufacturer to sell multiple units only because of the semiconductor's high reliability: if any one component in a multiple package were to change its characteristics, or fail, the whole package would have to be rejected.

Circuit designers recently have reported great strides in their efforts to build microminiature electronic equipment. One thousand of the smallest commercial transistors, widely used in hearing aids, occupy only one cubic inch.

Circuit modules have been constructed so compactly that 2,800 components are packed into the cubic inch by assembling unpackaged semiconductor diodes, transistors, and other elements, and subsequently encapsulating to protect the sensitive elements.

This example of creative packaging points up the manner in which new electronic techniques are made possible by imaginative use of solid-state electronic components.

Tomorrow's shapes— with today's limitations

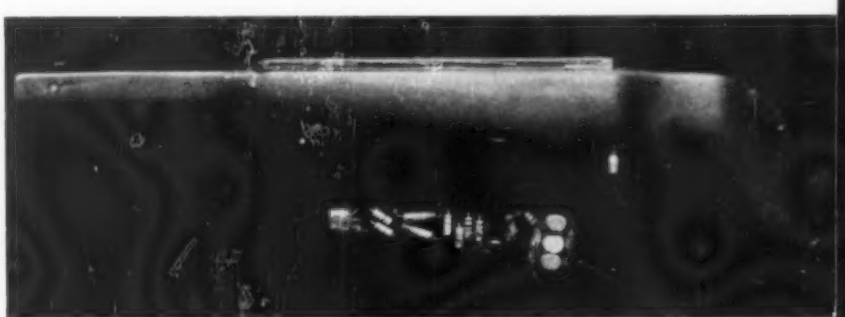
Steady efforts are being made to overcome limitations of today's semiconductor devices. The power-handling capacity of both rectifiers and transistors can be expanded through present scientific knowledge. There is little question concerning feasibility of manufacturing very high power devices; *the outstanding problems here lie in marketing and economics.*

The limit of high frequency performance falls in a somewhat different category. This barrier is imposed, for conventional transistors, because it is impractical to reduce the size of their active regions much further.

Ingenuity of fabrication and the introduction of new techniques (for example, the fabrication of junctions by solid state diffusion) have pushed the upper limit of operating frequency of transistors to several hundred megacycles per second. However, any significant advance beyond this point will require new basic knowledge and invention.

Semiconductor amplifiers and oscillators for much higher frequency operation are likely to differ substantially from conventional transistors in both mode of operation and geometrical arrangement. Several promising approaches to the problem are undergoing intensive investigation in re-

In 11 years since Bell Labs' introduction of the transistor, this most widely used



BONE-CONDUCTION HEARING-AID-GLASSES, *powered directly by light instead of batteries, are possible only because of the development of semiconductors.*

THE AUTHORS

Raytheon's Walter F. Leverton and David Rubinfien are good examples of today's industrialists-scientists. Dr. Leverton, who earned his Ph.D. in physics at the U. of Columbia, taught at the U. of Minnesota before joining Raytheon, where for the past six years he has been manager of physical electronics in the research division. Rubinfien, as manager of marketing services in Raytheon's semiconductor division, is a kind of salesman; yet he's also a first-rate mathematician and physicist who has done considerable research work. He holds a master's degree in these fields (from Illinois Tech) and another one in business administration (U. of Chicago).

search and development laboratories.

One solution involves a direct effort to reduce the transit time. This is the time required for electrical carriers to traverse the active region of the device; it is the principal limitation on high frequency performance of transistors.

The high electric field in the neighborhood of a reverse biased semiconductor junction will accelerate carriers to high velocities. Successful design of devices in which the active region is contained in this high field should result in a real breakthrough to very short transit-time devices.

One such approach to high frequency semiconductor devices is the "Spacistor" under development at Raytheon. A quite different approach to high frequency amplification, it involves the application of an old idea made practical by recent developments in the semiconductor field. This is the parametric amplifier making use of the variation of electrical capacitance with voltage applied to a semiconductor diode.

Specially designed experimental diodes have been operated successfully as amplifiers and oscillators up to microwave frequencies. To those familiar with present-day noise levels in amplifying devices, the most exciting feature of the parametric amplifier is its extremely low noise level.

A third limitation of present day semiconductor devices is that of operating voltage. While the present peak voltage specifications somewhat limit the application of transistors, it is in diodes that the drawback is really serious. Few commercial diodes with peak inverse voltage ratings above 1,000 volts are available even though laboratory specimens operating over 5,000 volts have been reported.

Potential applications for diodes of 1,500 to 3,000 volts are numerous. Many important applications require specifications at 20,000 volts, 40,000 volts, and higher.

Without doubt, the future will see diodes developed to operate reliably throughout this range, as no major theoretical or technological developments are required to make this possible. In fact, current laboratory studies of ultra-pure and extremely perfect silicon singie crystals strongly indicate the development of such high voltage diodes.

The day after tomorrow

Future developments discussed to this point involve tailoring devices from well-understood materials and utilizing known principles to perform well-defined functions. While it is certain that availability of such devices will generate important applications as yet unconceived, the really amazing successes of the future in this field may be wrapped up in the unique properties of new semiconductor materials.

The "three-five" compounds probably are the most widely studied group of new semiconductor materials. These compounds derive their name because they contain equal numbers of atoms of one element from the third column of the periodic table (aluminum, gallium, or indium) and of another element from the fifth column (phosphorous, arsenic, antimony).

Certain members of this family of compounds are distinguished by electron mobility much larger than that in germanium or silicon. (Mobility is a measure of the ease with which a free electron in the material is accelerated by an electric field.)

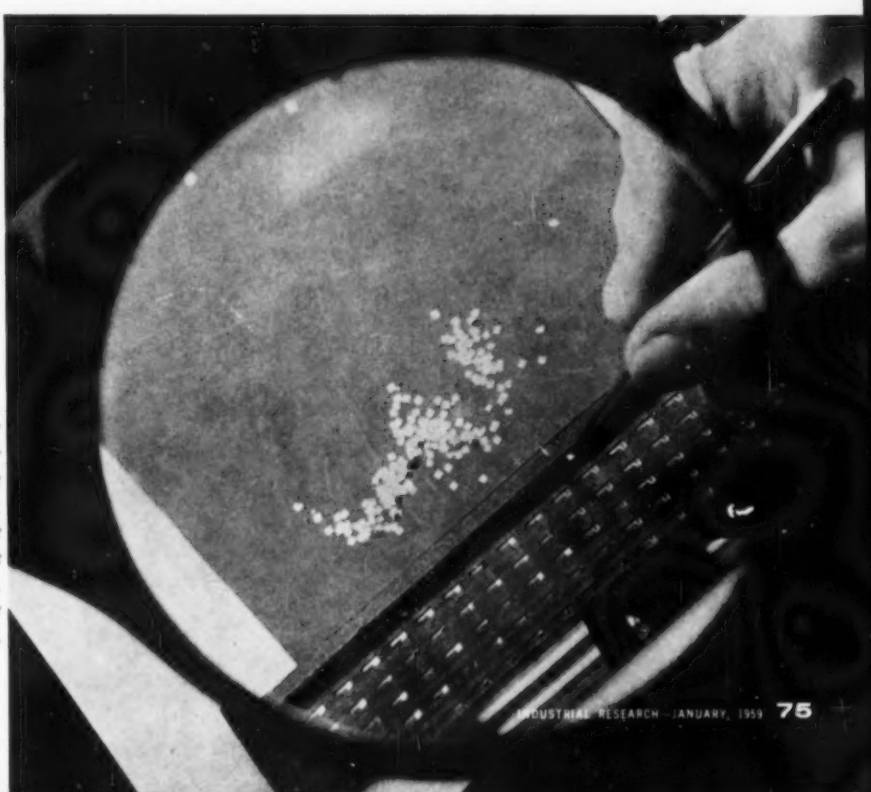
Other three-five compounds hold promise as basic materials for the design of semiconductor devices capable of operating at higher temperatures than is possible using silicon.

Silicon carbide is another semiconductor undergoing intensive study. Experimental diodes constructed from this material already have demonstrated some of the predicted and desirable very high temperature operation.

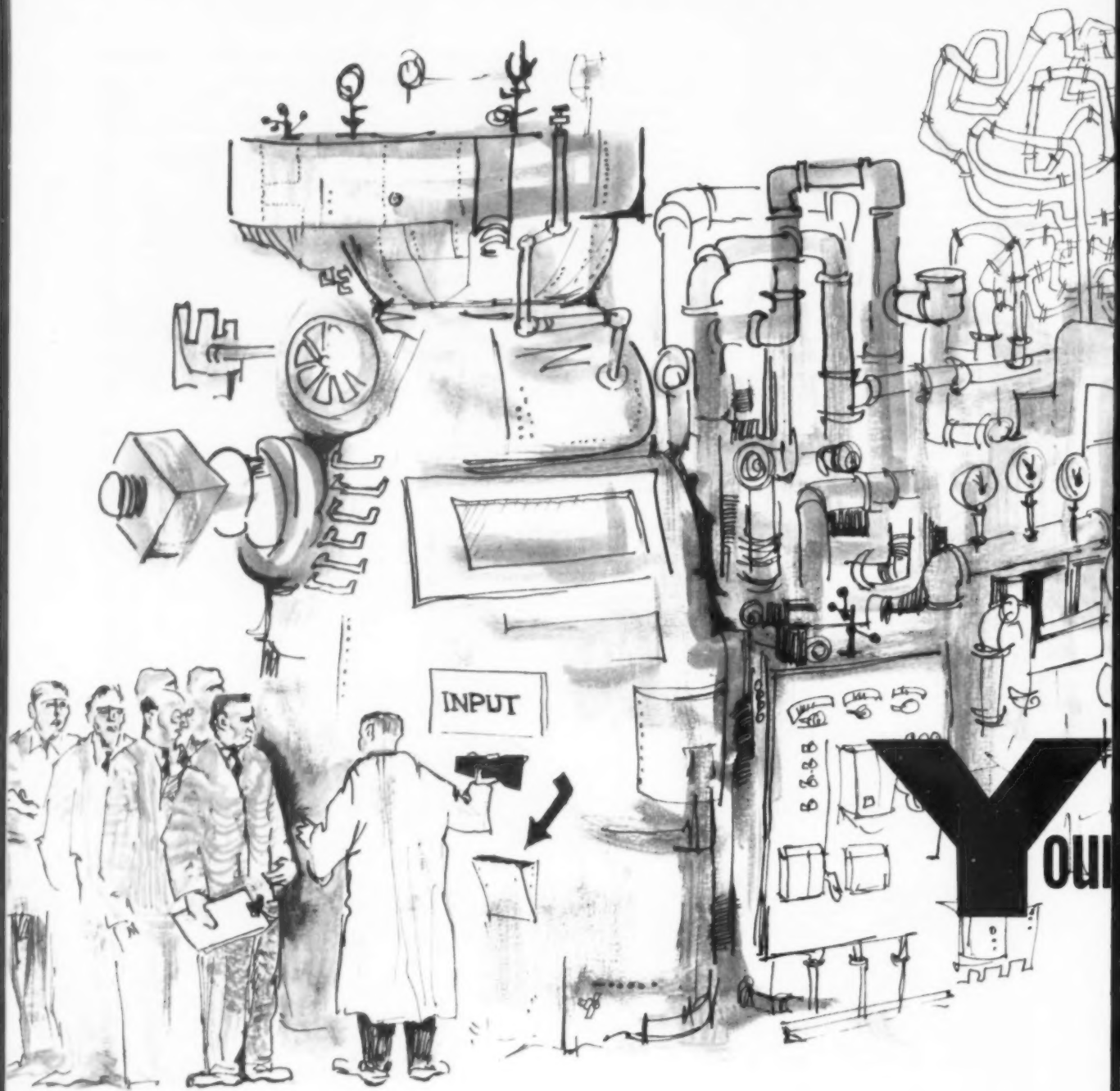
Progress with silicon carbide is stymied at present. The difficulty lies in preparing the material in single crystals of sufficient size and purity to

continued on page 86

semiconductor now is being manufactured by 55 companies in the United States and 37 others in 10 foreign countries, notably Japan.



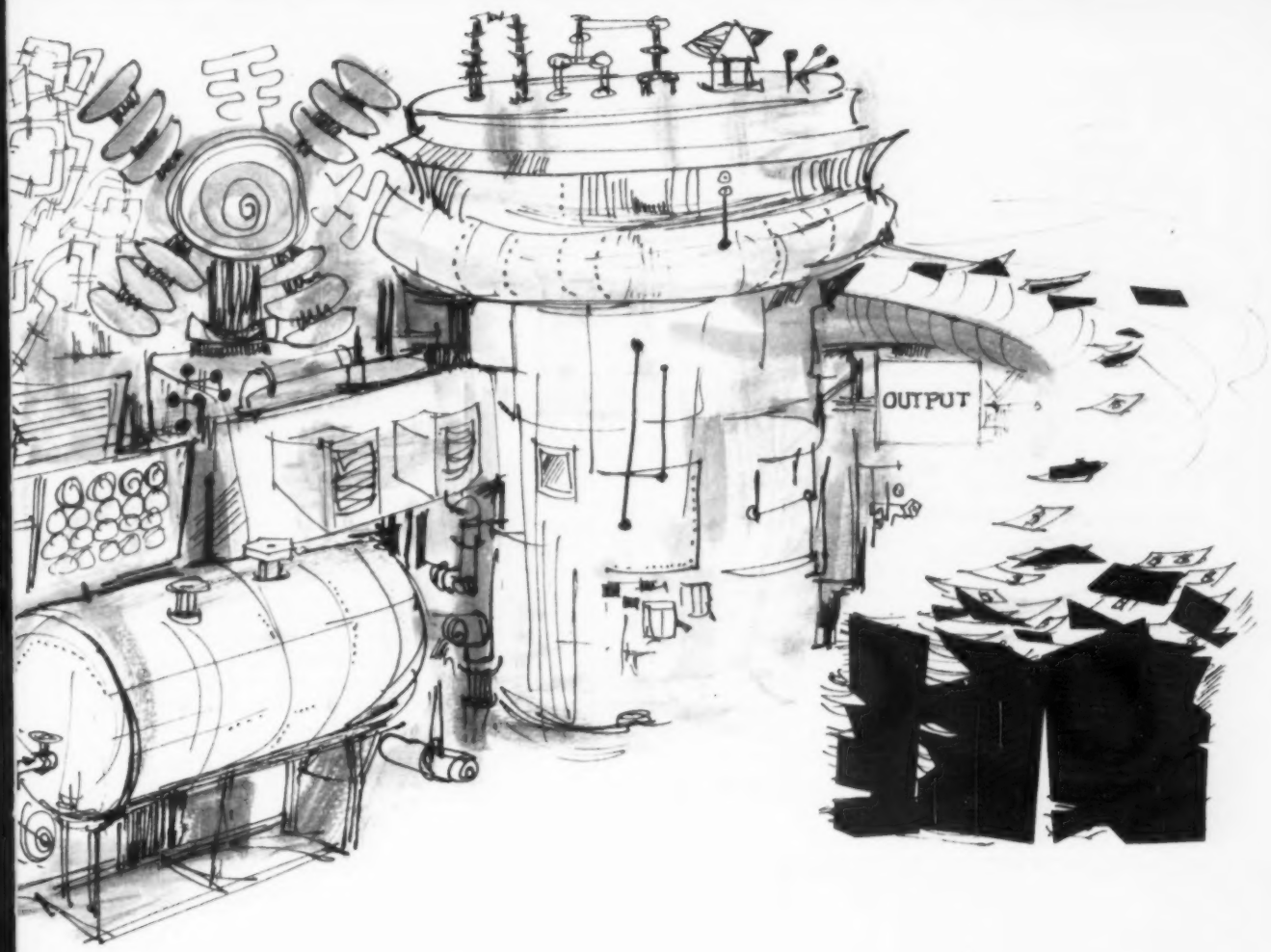
SORTING *of semiconductor materials for some 20 transistor characteristics proceeds at 400 to 600 units an hour. Photo at right shows what the woman above sees through her magnifying glass. Rubber gloves protect the to-be transistors from contamination.*



EVERY DOLLAR *fed into the gigantic research complex of 1959 will return $100 to $200. But it will take from three to seven years before results become noticeable.*

Research is like the rather elaborate slot machine pictured on these pages: if you put in enough investment and wait enough time, the pay-off may be large. Skillful management based on an understanding of the research process can make the returns on this investment somewhat more certain and well worth the waiting.

American industry now has enough experience with research to make this understanding available to those who truly seek it.



dollar returns from research

Latest surveys show how research has paid off in profits for your competitors, the percentage they spend for research, their attitudes toward it. How does your company compare?

by Dr. Irving Telling and Warren S. Berg, A. D. Little Inc.

"Research has meant the difference between growth and stagnation so that 90 cents out of every Minnesota Mining sales dollar now comes from products developed by research," according to 3-M president, Herbert P. Buetow. Statements like this can be made of DuPont, RCA, and other research-based companies.

Rarely, however, does research pay off as dramatically as it did for the family-owned American Paper Goods Co., which used outside research on a new product to obtain better than bank-rate returns on its idle capital. The consultant conducted a market study and found that a paper cup suitable for hot drinks was a promising possibility. The research team then developed a non-toxic, tasteless plastic to coat the inside of the cup for greater strength and durability and, in conjunction with the client's engineers, designed and built the coating machinery.

Even before the interesting new product was ready for marketing, a large container company bought up A.P.G., providing the owners with unexpected large

returns on their investment.

Dr. Raymond H. Ewell, formerly of the National Science Foundation, has calculated that research money yields an annual average return of 100% to 200% over a 25-year period. He compared this national figure with such industrial experiences as one chemical company's estimated 200% per year return over a 12-year period from its research. This would indicate that research does pay off like a slot machine.

The analogy is not too far-fetched, for slot machines sometimes absorb a good deal of capital and have been known to hit the jackpot with discouragingly low frequency. In fact, 80% of new products fail.

New products can succeed

New products need not fail 80% of the time, however, and the odds are improved by skillful management. Understanding of the practice of research and development is one reason why men like William C. Decker, president of Corning Glass Works, can record that only one quarter of his company's present business comes from products more than 15 years old.

This understanding exists among many in the ranks of management today because American industry has considerable experience with research. Eleven billion dollars is the estimate of the total 1958 investment in this activity; that's really feeding the slot machine! Elsewhere in this issue are predictions of a $12 billion investment for this year!

As Esso's E. Duer Reeves commented a few years ago, research is an industry in its own right now, contributing a significant percentage to the gross national product each year.

The most impressive growth of this industry has occurred since 1948: from $2 billion to $11 billion in a decade. Such mushrooming of a single activity is bound to attract attention. Articles, books, dissertations of diligent graduate students, conferences, and workshops have explored the phenomenon in detail, especially the problems and techniques of research management.

So much research on research plus the experience acquired from practicing the object of all this study has developed considerable sagacity. And more is being added every year.

Godly reception

Industry was not always of this mind. It is said that when Arthur Dehon Little sought $50,000 in New England to obtain the American rights to the Cross & Bevan viscose process about 60 years ago, he was given the same kind of reception he met a few years later when he wanted to develop cellulose acetate:

"Do you mean to say, Dr. Little, that man can ever produce fibers as good as those God has provided us?"

The viscose process today is the basis of the $420 million viscose rayon industry.

Challenged by the general lack of technological vision, Dr. Little devoted much of his life to preaching industry's need for research. He wrote extensively about scientists — the Fifth Estate, he called them: ". . . those having the simplicity to wonder, the ability to question, the power to generalize, the capacity to apply . . ." He made a silk purse out of sows' ears to give the lie to those who excused a lack of imagination by quoting folk sayings.

The experience of World War II gave the final impetus to industry's gradual conversion to the research doctrine until today, when it is a brave board chairman who does not report some kind of research effort to his stockholders.

Research programs: their care and handling

Having made an investment in research, however, how can you optimize the return? One of the first things is to know what kind of research you have undertaken. Without this understanding, you will never know where or when to look for your returns.

". . . To be effective, research programs must be continuous. You

Warren S. Berg

Dr. Irving Telling

them on and off like a faucet. They must never be a function of

THE AUTHORS

Old pros at advising companies how to hit the research jackpot, Dr. Irving Telling and Warren S. Berg direct the public relations and business development activities (respectively) at Arthur D. Little Inc. Both are former faculty members of MIT and graduates of Harvard. Telling taught at the U. of Massachusetts; Berg, an engineer, taught at Harvard College.

Quality control and technical service to sales or production are necessary. But they are not research. Yet, how often do R & D personnel spend their time on these duties and never have a chance to make a research payoff possible?

Product or process improvement is the beginning of true R & D, and takes an average of one to two years to complete. New product or process development frequently takes longer.

Fundamental, or basic, research is a real gamble, for here the scientist is seeking new knowledge, not merely applying what is known to a specific end. Yet basic research is what turns up the wholly new materials that may pay off handsomely when their uses are clear. Time in the laboratory is more difficult to predict for basic work, and development work will probably have to follow; say four to 10 years.

Technical manpower then, can be used for many different purposes. Management can measure the returns only when it has a clear idea of where the effort is being applied and, hence, what kind of return can be expected.

can't turn

fluctuating sales..."

It is not enough to buy some technology (put money in the slot machine) and watch it pay off. If new products are wanted, quality control or technical service won't produce them, and basic research may provide the only means for obtaining them.

Vital in planning a new product program that can pay off is the effort to be spent outside the laboratory in production preparation, market testing, product modification, and market development. Thus it is usual to say that five years will go into product development and two into market development.

The latter is the area from which comes much of the high failure rate for new products — management does not understand the market well enough to develop a marketable product, or does too little to develop the consumers' appetites.

Research alone will not produce a jackpot. It can provide the means for winning the big money if management knows how to take advantage of the opportunity through executive decisions, skillful engineering, good plant operations, clever marketing, and the like.

"The inescapable fact," according to one company official, "is that research is simply one of several vital factors in the success of a business. The separation from the total mix of the research portion defies even the most comprehensive analytical methods."

Payoff, then, is no immediate certainty; it takes time and the combined efforts of all a company's departments.

Jackpot requisites

Obviously the research and development staff must first produce something on which the rest of the company can capitalize. Skillful management is another requisite. One of the aspects of this is a clear idea of company objectives and their communication to the technical staff. Without such guidance the research director will have difficulty in selecting appropriate areas of investigation.

While such a statement may seem too self-evident for emphasis, the error is all too common. A cross-sectional sample of the many surveys of research activities made by A. D. Little Inc. indicates that a majority of companies have been remiss in this matter. In almost all cases, top management lacked a thorough understanding of R & D, what it could and should do, and how to use it. Little wonder that a large number were devoting too much time to defensive research and many were using their technical people primarily for service work in sales or production.

V-Ps of research needed

Several remedies suggest themselves. One or more technically oriented men on the board of directors and in the ranks of top management will help to clarify and support research planning. When the research director himself is a vice-president and has both equal status and constant communication with the other top officers, his work will relate more realistically to that of the company as a whole.

Frequently an R & D advisory group proves useful in screening projects before they go into the laboratory and after work has been under way. By this means, interesting but irrelevant or unrealistic ideas do not get started, and time and money will not be wasted unduly.

Underlying most of these suggestions is the need for communication within the R & D staff and with other departments. Lack of this showed up in a high percentage of companies in the surveys mentioned above. Unless the operating divisions are kept informed of the progress of technical work and its profit potentials, they neither can be prepared to take advantage of it nor can they be expected to show much interest.

Answers without questions

And the research group must have some check on the relevance of its work. An executive summed up the problem succinctly: "This emphasis on communications should include periodic matching of research objectives with overall company policy. Policies change with time. There is scarcely anything more frustrating than an answer, the question for which no longer exists."

The only realistic retort to management's concern with the correct percentage of sales to be spent on research is that there is no magic number. The range is wide.

The food industry as a whole is on the low side, averaging about 1% or less. In electronics and instrumentation, however, the amount may reach 10 to 15%. It seems to be true that the growth industries generally spend at a high rate. The chemical industry now is putting about 4% of sales into research — twice the rate of 10 years ago.

Minnesota Mining & Manufacturing reports it is budgeting about 4.5% of sales into research. Result: 3-M salesmen have a new product to talk about four times a year and almost a complete new line every three years.

A better guide than tying your research budget to a fixed percentage of sales is to examine the company's needs in terms of its corporate plans and its competition. When a company loses sales because of technical superiority of a competitor's product, the need for research becomes painfully evident.

Research programs to be effective must be continuous, not turned on and off like a faucet — as so often is the

case where budgets are a function of fluctuating sales.

To play or not to play

To understand the facts of research life is to share in the growing rewards. It is knowing something of the odds built into the slot machine. You gamble less when you make your investment because you know how the machine works. *In fact, not to play is becoming the greater gamble.*

The increase in research has speeded change to a point unknown to an earlier generation. Long-range planning is now essential and much more difficult. Defensive research is necessary merely to stay in the game; only aggressive, creative research permits significant growth and profits.

The 11% of their budgets that small companies invest in outside contract research is not surprising, for they cannot afford to maintain elaborate research staffs housed in academic or palatial centers. Indeed research expenditures necessarily take a larger proportion of the available funds of a small business, and the smaller the company the greater the tingle in the pocketbook nerve.

Yet research is as necessary to small companies with their less extensive product lines as it is to industrial giants. Many industrial yeomen are coming to realize this. The Wilner Wood Products Co., of Norway, Maine, turned to Arthur D. Little Inc. a few years ago for advice on utilization of waste wood fiber. Today the company makes a substantial profit from this former waste material, has acquired considerable research experience, and uses the consultants as its technical staff.

Competition on any scale indicates a need for research. It is a truism that a company today either creates change or becomes its victim. Nothing is as constant as change in the competitive world.

One of the areas of payoff from research derives from the very size of this activity and benefits both small and large concerns. This is the production of equipment for the growing research market. Baird-Atomic Inc., of Cambridge, Mass., began 20 years ago when Walter S. Baird developed a spectrograph for metallurgical analysis that was simpler to use in a laboratory.

Today his company produces a varied line of research instruments such as an infrared double-beam recording spectrophotometer for organic chemical analysis. Recent merger with a small firm added a full line of electronic equipment for nuclear research.

Similar experiences are doubtless widespread. In New England such research-based companies thrive in the technological atmosphere created by Harvard and MIT, and have contributed to the region's economic revival.

New products

Dollar returns from research are most readily apparent in the field of new products. Be these improvements in existing items or products wholly new in concept, they can mean more sales in present markets or an extension into different markets.

Additions to a product line provide greater stability of profits. In either case, the investment in research is paying off. Diamond Expansion Bolt Co. Inc., of Garwood, N. J., for example found it embarrassing to carry competitors' hollow-wall fasteners to complete its product line. Yet this popular type of fastener seemed to be completely covered by patents. This fastener is inserted into a hollow wall, and when the central screw is turned, it pulls three or more legs tight against the inside of the wall to hold the fastener.

Engineering research produced a new, patentable fastener that changed the profit picture on this item. The research program was extended to include the design of production machinery and automatic assembly equipment. In this case, a new product with greater profit potential was not the only return.

New markets

New markets can be one of the returns that research makes, sometimes quite unexpectedly. A small atomic clock is under development at A. D. Little for the Army Signal Corps. The demand for a clock that will lose or gain no more than 1/1000 of a second over a year's time does not seem great.

Yet 10 years ago, A. D. Little anticipated it would make no more than three or four of the helium liquefiers — cryostats — developed with Prof. Samuel Collins, of MIT. But by the end of 1958, cryostat number 144 was in the works.

So also a filter capable of removing 99.98% of particles from the air was developed for the AEC to screen out radioactive dust. Today at least two companies, Cambridge Filter Corp. and Mine Safety Appliances Co., are producing these filters for many industrial uses as well as for the AEC.

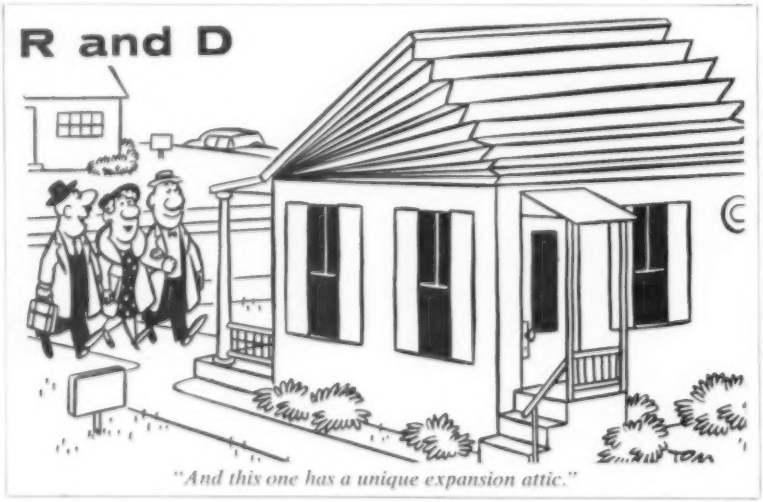
In a less exotic vein, the Sanborn Co., in Waltham, needed a better paper for recording the readings from its electrocardiograph equipment. Research produced a completely different concept that provided a recording paper capable of receiving very rapid signals in permanent and immediately useable form. In a new, enlarged plant, the company today is producing a varied line of both medical and industrial measuring equipment using this new recording medium.

Technology has advanced today to the point where "common sense" solutions are not always possible. Research staffs should be able to use their specialized skill and knowledge for scientific solutions.

When RCA was developing a color TV tube, for instance, difficulties arose over obtaining uniformity in the phosphor coatings on the screen. Mathematicians explored the theoretical limitations of increasing this uniformity, and experimental tests vindicated their solution.

New processes

Products are not the only area where payoff appears. Production savings can achieve the same result. Engineering research developed a process using high pressure blowing to increase the efficiency of blast furnace



"And this one has a unique expansion attic."

operation. Republic Steel was the first to install the process, and today it is in general use throughout the world, with savings per ton of pig iron and a possible 10 to 15% increase in output.

In the paper industry, about 20 years elapsed before the neutral sulphite semichemical pulping process developed at the Forest Products Laboratory in Madison, Wis., was adopted widely. Here a neutral pulping solution gives a high yield from hardwoods, and the product is widely used for the corrugated center in cardboards.

Like new products, new processes permit the exploitation of opportunities otherwise unavailable. The fluidized bed process, developed by Prof. Warren K. Lewis, at MIT, as a consultant to Esso Research for the catalytic cracking of petroleum, is a technique in which intimate contact between gases and solids are achieved.

More recently it has been under development for the direct reduction of iron ores with gaseous fuels, in contrast to the conventional reduction method — the blast furnace — which demands high quality coking coals. Another advantage results from relatively small units that can be economically justified to supply small markets. The payoff from this process in the metals industry is yet to come, but several large companies have faith in its potentialities.

Problem processes

Research can make significant returns when processes which present problems arise. When the Quincy Market Cold Storage & Warehouse Co. recently found its brine pipes were leaking, it faced a problem of real magnitude. The pipes went under the city streets to local firms to which the cold storage company furnished this refrigerant. Tearing up the streets and repiping the system would make such repairs prohibitively costly.

Research came up with a compound that could be poured into the piping system to seal the leaks. The modest investment in research now is paying off at better than five to one, in maintenance and operating savings alone.

Production machinery, like processes, are research products that can make significant savings. Computers, for example, are so complex that months are needed to build them (because the relatively restricted market makes elaborate machinery prohibitive). IBM turned to engineering consultants for a machine to assemble cores and wires in the magnetic core memory of the 704 computer. The result was a device that did the job in 15 minutes instead of the nearly 30

ATOMIC CLOCK *experiment involves A. D. Little's William Martin in observations of light transients in optically pumped sodium vapor. Object is to find materials useful in atomic frequency standards.*

hours required for hand assembly.

Noteworthy in research is the interdependence of disciplines. The management of production is increasingly dependent on operations research — the use of the scientific method and mathematical techniques to assist decision-making. So common is this practice in most large corporations that one can easily forget that research is basic in its use.

But in addition to production planning and inventory control, a wide variety of other applications are possible. One company used this research tool to decide where to distribute its catalogues for optimum effect. The same technique can help in more effective use of human sales representatives.

Customer decay rate

Concerning selling, the OR staff at A. D. Little is examining the effectiveness of advertising practices for some clients. Operations researchers have discovered that customers tend to stop buying at a fairly uniform "decay rate," and advertising appears to be chiefly useful in attracting new buyers, although each medium used has a "saturation level."

Mathematics also can be used to enable computers to do much of the "dog work" in engineering. The power piping division of Blaw-Knox, for example, now can figure in a matter of hours the stress analysis of the complex piping system of a large power installation, a job which formerly consumed weeks of engineering talent.

Research is opening up this whole area, and it is becoming feasible to expect a computer to figure out an optimum structural design or the most promising chemical formulations for desired specifications — within the limits of data supplied.

The social sciences, too, are coming up with new insights and skills to assist management. Intensive investigation of group dynamics is increasing our understanding of the ways men work together, and managers are beginning to use these research findings like any others for more effective results. The marketing equivalent is motivation research. The example below shows a typical payoff from their research.

Several years ago a psychologist began a study for a powdered coffee manufacturer to determine why sales were slow. He began by asking a number of women why they didn't use instant coffee.

"We don't like the taste," they told him.

Since this sounded like a stereotyped answer for a much more complex situation, the psychologist set up an experiment to probe the matter further. He drew up two shopping lists, identical except for one item — coffee. The first list included instant coffee; the other incorporated the drip-grind variety.

Each list was given to 50 women. They were asked to paint a word picture of the sort of woman who might go to the store with such a list.

Almost half of the women who worked from the list having instant coffee said that it represented a lazy woman and one who would not plan her purchases well. Twelve per cent thought she was a spendthrift, and 16% went so far as to say she was not a good wife!

The women who worked from the list which included drip-grind coffee drew a different picture. Only 4% saw laziness, and none saw signs of a spendthrift or a bad wife.

This experiment revealed to the coffee manufacturer that his instant coffee gave women a picture of themselves they didn't like. He changed his advertising message— and the image of the consumer. The product was presented to show good planning and thrifty buying. The sales response improved remarkably.

Are the possibilities exhausted?

It almost seems that the explosive expansion of research in the last decade must have exhausted the possibilities for new dollar returns. Actually the returns are just beginning to come in. The delay between investment and returns means that we shall be feeling the impact increasingly as time goes on.

The growing use of research by industry can continue for many years; only a fraction of the companies and trade associations now take advantage of the potentialities of technology.

The cycle is almost self-generating: when a few companies invest in research, their competitors must follow, and thus they are led on to aggressive research. Finally, the very nature of scientific research and scientists means that new developments and improvements in research itself are inevitable. We are on the verge of a still greater expansion — with its proportionate dollar returns. ■

"We have a safety system of keeping our employes from wandering and getting hurt."

tape recording

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the test program stays intact and is instantly repeatable.

To insure that components furnished by co-contractors and sub-contractors are given correct shake-table testing, JPL sometimes provides the program tapes. Thus a similar shake-table installation in another part of the country can precisely duplicate the tests run in the JPL laboratory. Any number of duplicate program tapes can be made, enabling wide dissemination of a well-conceived test program.

Many users of magnetic tape instrumentation have added wheels to their test equipment. One manufacturer of turbo-jet engines, has put magnetic tape to work in a complete mobile tape laboratory which houses all the necessary on-the-spot instrumentation for a string of jet test cells. Equipped to record the output from any type transducer, the laboratory-on-wheels measures temperatures, pressures, flow rates, thrust, acceleration, and other variables in proper time relationship.

Upon playback, in conjunction with a fixed laboratory tape data reduction installation, the recorded information can be processed in expanded, compressed, or true time, through oscillographic equipment, harmonic and spectrum analyzers, and other data processing equipment.

A significant feature of this manufacturer's tape recording setup is that it is a completely integrated installation, built to the specific requirements of the string of test cells.

Tape in space

Magnetic tape's original "instrumentation" application, developed about 10 years ago, was to record telemetered signals for later study. This fits in well with space activities.

In a satellite launching, for example, there may be a tape recorder in the satellite itself, in the missile which carries it into space, in the control room at the launching site, and in dozens of tracking stations scattered throughout the globe. With the aid of telemeter links, data is acquired on magnetic tape as soon as it's generated, before, during, and after launching.

At some flight-test centers, magnetic tape serves as a common denominator on which all primary data is recorded. Some data is acquired by airborne tape instrumentation, some is telemetered to the ground, and some is telemetered from radar tracking stations. The taped information from all these sources is fed to a central data processing system, where it can be inspected easily by pen-and-ink readout.

Change-of-time scale

Magnetic tape's ability to compress or expand the time base has qualified it for use in a number of interesting applications where the information occurs too rapidly—or too slowly—to be recorded by other means.

For example, in a study of ship motion at sea (on the S.S. Mariposa), the frequencies encountered were well below one cycle per second—much too slow for analysis by conventional wave analyzers. By recording on tape at 1⅞ inches per second and speeding up by a factor of 1024 to 1, the frequencies were brought to a level where separation and measurement by wave-analysis equipment were an easy matter.

In another application, the reverse treatment was necessary. An aircraft manufacturer was experiencing shock problems from the firing of a plane's armament, but was unable to evaluate the shock data by ordinary methods.

By recording the shock waves on magnetic tape and slowing them down so that a thousandths of a second was stretched to a full second, it became possible to use the recorded signal to write out a visual trace. Thus the exact extent and nature of the shock pattern became clearly evident, as well as the manner in which it was transmitted through the plane's structure.

Tape's magic memory is at work under the sea, as elsewhere. U.S. Navy submarines carry tape recorders which can capture (for training and study) the ping of a sonar echo from a school of fish, the underwater sounds of a ship's propeller, or the swish of bubbles from the sub's own wake.

In an application which rivals a trip with Jules Verne, a miniaturized tape recorder has been designed to ride a Polaris missile when fired from underwater. The most critical moments of a Polaris flight occur from the time the missile leaves its submarine launching platform until it's safely airborne.

To get a complete record of these critical moments, the piggy-back recorder hitches a ride in the launching pod, falls free after the missile and pod separate, and is recovered for analysis.

These are some of the diversified tape recording practices in use today. They're a far cry from the "exclusive" home entertainment uses of not too many years ago. And—as Marvin Camras writes in the accompanying article—they're equally limited compared to the promising possibilities now being researched in the laboratory. ■

comment

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Chemical, GE, Huggins Labs, IBM, ITT Corp., Lenkurt Electric, Levinthal Electronic, Link Aviation, Lockheed Missiles, Microwave Engineering Labs, Palo Alto Engineering, Philco, Shockley Semiconductor Labs (of Beckman Industries), Sperry Gyroscope, Stanford Research, Sylvania, Varian Assoc., and Westinghouse.

Outstanding feature of the Honors Cooperative Program is that it gives the same quality instruction to industry students as to regular university students. The industrial students must meet established high academic standards. They compete with full-time graduate students, rather than with each other as is usually the case in industry classes.

The companies benefit, of course, by their employes' increased knowledge. Recruiting-wise it's attractive to offer technical men the opportunity to work toward an advanced degree while earning a salary.

One comparatively minor disadvantage:

For a small company the outlay of money and employe time can be a hardship, or an impossibility. (Each company pays the university about $500 per year per student.)

Initiator of the plan is Dr. Fred E. Terman, provost of the university; administrator is L. Farrell McGhie, associate dean.

R & D contracts

■ A three-year Air Force contract for $11 million as a first-year starter has been awarded to Bendix Aviation Corp. to develop an airborne weather system. Bendix is attempting to devise a system for jet aircraft in flight to be used as flying weather stations—10 miles up at slightly below the speed of sound.

■ The final engineering design of a large-scale nuclear reactor to cost $145 million has been assigned to General Electric by the AEC. The reactor, to be built at the Hanford Works, will be designed to produce nuclear materials with the possibility of later conversion for power.

■ Ways to control growth of trees without impairing their health or appearance is being explored in a five-year research program at Battelle. Sponsored by Edison Electric Institute, the point of the research is to maintain adequate tree clearance on pole lines.

■ Development, production, and maintenance of several new guided missile computers for the Nike-Zeus anti-missile program are included in a $20 million order awarded by the Army to Rem-Rand Univac Division. Bell Telephone Labs will participate.

■ Problem of flight control for manned

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advanced future airliners are in full-test dreaming, planning, and designing stages.

In one of these stages is a supersonic VTOL airliner that Ryan reportedly is researching. Ducted fans, buried in the wings, would provide vertical lift.

In England, two delta-winged Mach-2½ transports have been proposed, one by Dr. A. A. Griffith of Rolls Royce; the other by Dr. B. N. Wallis of Vickers-Armstrong Co. Sweepback of wings on both ships would be an extreme 75 degrees. While this shape is excellent for cruising speeds, it causes problems at landing and takeoff because its lifting force is best when the craft is at an extreme angle to the ground. Diving into the runway at the necessary attack angle would be too much for almost any conceivable landing gear.

Griffith's answer is to replace wing lift entirely with jet lift during landing and takeoff, using a battery of about 100 small turbojets ranked along the windowless fuselage for the vertical push—for a few minutes during each flight.

Since wing shape is the cause of low-speed difficulty in the delta-winged craft, Wallis solves the problem by changing the shape of his wing. For coming onto and leaving the runway, his swallow-tail delta wing (hinged probably on a big ball-and-socket joint) would swing out at right angles to the fuselage and give extra lift. The wing's center of lift could be changed at will relative to the center of gravity of the whole airliner.

Turbojets for this polymorph transport would be carried in double-deck wingtip pods, free to pivot for controlling pitch, roll, and cruising thrust. A range as high as 15,000 miles is envisioned.

Features remindful of both these British projects would be used in a Mach-3½ VTOL transport which the NACA is researching. A model of a big delta-winged craft similar to the Griffith ship will be test-flown as part of the research investigation.

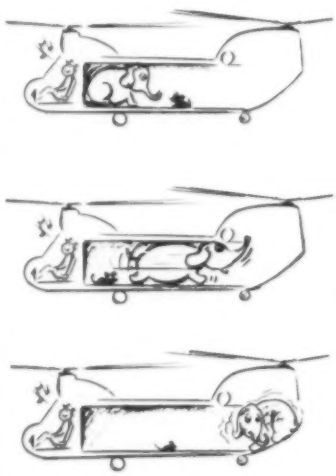
The finished airliner would weigh 400,000 pounds, carry 150 passengers, lift and settle vertically on the blasts of two under-belly batteries of 90 jets, and both lift and cruise on the thrust of the two wingtip clusters of four larger engines, pivoting for vertical and horizontal power.

Lockheed's Mach-3 transport is expected to have VTOL capability, flying 2,000 mph at a cruising altitude of 50- to 60,000 feet. Carrying 85 to 100 passengers for trips in stage lengths of 1,000 miles or more, its seat-mile cost might run 20% lower than that for the new subsonic jet airliner designs.

Douglas Aircraft is reported to be making progress on its plans for a Mach-2 transport, a plane based to a considerable degree on the firm's work with the DC-8. Boeing also is looking into the possibilities of supersonic airliner designs.

Developing a new transport is not a one or two-year project. Only after 13 years of research and testing was Boeing's 707 ready to be listed in the timetables.

Or was it?



Stability—par excellence!

High power=high noise

Noise turned out to be a major jet transport problem. New York, Los Angeles, London, and European cities have imposed sound-level or flight restrictions on the transports. To solve the problem, both Boeing and Douglas have designed sound suppressors which break up and channel the noise-making 765-mph exhaust blast through baffles of tubes or geometric openings.

Other solutions to jet noise also have been considered. Armour Research Foundation has shown that once weather conditions are known, the amount of noise striking at ground level can be predicted accurately. Sound-propagation weather reports, based on this method, might allow airlines to alter flight paths or use variable noise-suppressing systems.

Still another answer to the noise problem would be to base the jet transports on water instead of populated land areas. An example of the type of aircraft which could be used is the Martin *P6M SeaMaster*, a 600-mph Navy flying boat which can be brought up and onto land in a beaching vehicle controlled by the plane's pilot.

The noise investigation is just one example of the current intensive military-aviation activity. This research ranges from studying the grain structure of heat-resistant airframe metals (such as molybdenum) to researching the best ways of giving space fliers their food (such as meat and vegetable pastes).

Military aviation

It was nearly five years after the Wright brothers' first sorties at Kitty Hawk that the first military aviation flights were made in the United States. The date was Sept. 9, 1908; the airplane, a Wright *Type A*.

Today, in an era of intense military activity, this time lag seems unthinkable. In many areas, military and civil aircraft seem inevitably wedded, their R&D highly interrelated.

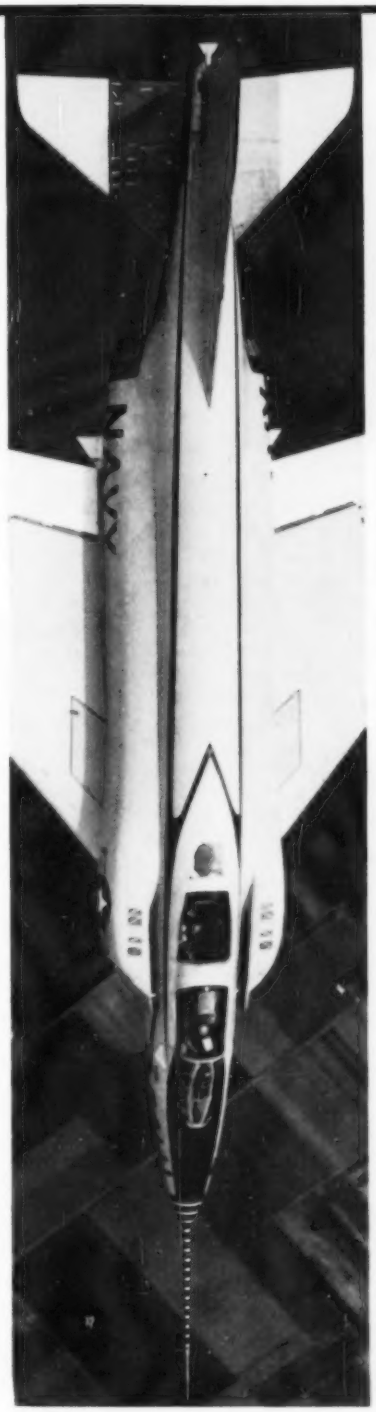
Operational experience with the F-104 Starfighter will help shape the supersonic design of Mach-3 civilian transports. Research, prototype development, and flight studies for Boeing's commercial 707 jet have helped give the Air Force its KC-135 jet tanker-transport. Operations of the tanker, in turn, have contributed to 707 development.

But the cost of developing and producing new military flying vehicles comes high—some 30% higher in 1958 than the year before. The Defense Department's approved budget for 1959 covers some $2 billion for research and development and $11 billion for buying aircraft and missiles. The R&D appropriation alone is $444 million higher than last year.

The force behind it all?

Facing bluntly against our air services are the swept wings of 21,000 Soviet military aircraft and nose cones of squadrons of Russian IRBM and perhaps ICBM missiles.

The U. S. military future rests on extremely fast intercontinental delivery of maximum armament. Current Air Force spending points to the missile as the ultimate form for making the delivery. The belief is that the United States is *at least* a year behind the U.S.S.R. in developing intermediate-range missiles. New spending for missiles in this country in 1959



GREATEST FIREPOWER *of any Navy jet fighter is clustered in the Mach-2 McDonnell F4H-1. Twin jets are mounted astride fuselage for fast carrier takeoffs.*

is expected to go up 43% (to $2.7 billion), while spending for manned aircraft probably will drop 5% (to slightly less than $4 billion).

Even with the shift in spending, manned aircraft developments continue in the lead. The emphasis is not necessarily contradictory. Rather it answers a single need required of both aircraft and missile designs: the need for quickly spanning great stretches of geography that lie between West and East.

Geography spanner

A good example is Canada's *Avro Arrow*, one of the biggest (30 tons) fighter-type aircraft yet built. Twin Pratt & Whitney J75 engines power the test craft. Even more powerful Orenda Iroquois engines, two of them, will be installed later, after the Arrow's structure has proven itself.

Speed and size of the CF-105 Arrow, big as many World War II bombers, were dictated by the job of carrying enough fuel and equipment, racing from area to area, defending the vastness of Canada in a day when missiles and electronic controls still have not been sufficiently perfected and are not plentiful enough to do the job.

This interceptor has been called potentially the world's fastest aircraft, although it has not reached any records in its speed trials so far. What it has reached, though, like some other supersonic craft, is the beginning of structural heating problems.

The plane has tremendous power. Even at its heaviest takeoff weight, the thrust-to-weight ratio is *one*—higher than any existent aircraft except VTOL models. Yet since air-friction heating problems begin between Mach 2 and Mach 3, the Arrow as currently conceived will be limited in speed despite any power it may have.

Manned flight is beset with such problems. Some say aerodynamic problems plus ingeniously steered remote controlled missiles already are obsoleting the highest-performing craft of today, including the F-104. The new flying machines, they contend, will not be manned at all.

Or will they? ■

EDITOR'S NOTE: *So that we may serve you better in future issues, we'd appreciate a postcard or letter ranking your interest in this and the other articles you read. Results will appear in a "Letters to I • R" column.*

Next issue:

The Flying Machine, Part 2, Spacecraft

While the airplane, as we have known it, is ending an era, flying is progressing faster and higher. In the next issue, the author will follow this progress: the mixed-engine vehicles that will take man beyond the last fringes of stratosphere, the guidance systems which will fly and yet not fly them. Also to be considered will be the ramjets, photonic drive, rocketships, and craft such as the Dyna-Soar hypersonic glider, which will skim a pilot through space at 18,000 mph.

comment

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space aircraft during and after entry into the atmosphere is being studied by Cornell Aeronautical Labs for the Air Force.

■ A $1 million plus contract has been awarded by the Signal Corps to Philco to design and build two medium size, mobile electronic data processors. Use is for combat computation.

Management and design

We've been asked: "Why the obviously expensive emphasis on design in a management magazine?"

Answer: Because we feel a management magazine should reflect what is important to management. Design enters, or should enter, into most management functions—certainly manufacturing, research, and marketing.

Good design should surround a good company. It should be inherent in a company's people, advertising, letterheads, and products. *Good or bad, design is your chronic display.*

One thousand of you may remember one of *I•R*'s preliminary surveys last March in which you were asked whether you'd like to see the proposed new magazine illustrated and presented attractively in the manner of leading consumer publications. Answers ran 51-49—only slightly in favor of good design. The other half answered that attractive design in a scientific management magazine was of little or no importance.

Later, in an informal, personal survey, two technical articles were left with a hundred busy technical executives. One article was titled in a provocative question and laid out with liberal use of color, photographs, and art illustrations.

The other was crowded in the manner of the worst trade magazines: the title was a complicated noun-adjective combination, type was jammed together on the page, photographs were small, and there was no art work.

Unknown to the subjects, both articles read exactly the same.

When asked which of the two the person would rather read, about half of the technical executives chose the dull-looking article. When asked why, they answered that it seemed more like the kind of article they had to read in order to find the information essential to their job.

Both articles were left with the subjects. When the questioners returned a week later and asked which of the two articles they had read, the answers almost invariably (94%) were that only the attractively-designed article had been read.

We—as you—favor good design.

—The editor

IR BOOKS OF THE QUARTER

Probably the most constructive of criticisms leveled against science, education, and government is Dr. Joseph W. Still's *Science and Education at the Crossroads.* (Public Affairs Press, 140 pp, $3.75)

Despite its prosaic title, the book offers an exciting view of contemporary life—a view from the laboratory. Still, a research M. D. known for his investigations into the cause of aging, and a contributing editor to this magazine, feels that our entire educational, scientific, and governmental systems are unsound.

He advocates strong federal control of schools, eliminating the thousands of unqualified local school boards; an organized system of interrelating scientific effort (today it often is cheaper to repeat research than to search archaically-organized libraries for a report of earlier work); and biology as a tool of diplomacy.

On the latter score, Still believes that U. S. aid to underdeveloped countries is not only just, but mandatory for the survival of civilization. He warns that unless we industrialize these areas—and soon—it will be too late to hold world population to 16 billion, the highest possible ceiling.

The ultimate end of the cold war, Still says, will be either one world or none. His plan for disarmament is to establish a "zone of peace" under a UN guarantee, first for underdeveloped nations, and ultimately for the big powers.

And what, you may ask, is a scientist doing talking about government and world peace?

Practicing what he preaches for one thing—that scientists must be represented in government.

One example: scientific research created DDT that wiped out typhus and other warm-climate insect-carried diseases. Yet, the millions who owe their lives to this American research are distrustful of us—mainly because of our government's failure, first to understand what we have accomplished, and then to follow through with other constructive scientific tools available in this nation.

★ ★ ★

For your sons: Stimulating teenagers toward worthwhile goals is not always easy, especially when father is the goal. Many industrial executives started out as scientists and engineers; many wish they did. At any rate, few doubt the value of a scientific education for their offspring, but note a lack of interest or outside stimulation.

A series of books *of fiction* have been issued by Popular Mechanics Press to provide such a stimulant to boys nine to 16. The latest two, written by Neil P. Ruzic, editor of this magazine, are *There's Adventure in Civil Engineering* and *There's Adventure in Meteorology* (187 and 166 pp respectively, $2.95 ea.)

The *Civil Engineering* book leads Randy, 16, and his brother Sam, 9, on an adventure from Alaska to Cape Horn. Through North, Central, and South America, they live the design and construction of highways, bridges, tunnels, and canals.

In *There's Adventure in Meteorology*, Randy and Sam stowaway on a weather plane that flies into a hurricane. Marooned on an island, they learn to build their own weather instruments as an aid to survival. Elsewhere in the book, they meet IGY researchers, visit weather stations, and learn about the natural forces that affect man's environment.

More than for their specific subject matter, these books are worthwhile because they explain the value of science to industry and society, and emphasize the scientific method as an aid to everyday thinking. Both books have frequent illustrations. ■

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semiconductors

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permit reliable measurement of its properties, or to permit the design of improved devices.

Beyond transistors

Although the transistor has launched the great study of semiconductors, they are no longer the only "miracle" devices. Other semiconductor devices are finding important markets and contributing to the rapid growth of the industry. This fact, often overlooked, is an important clue to the future of the semiconductor industry.

Paralleling rather specialized vacuum and gas tubes designed for more restricted applications are several recent specialty semiconductor devices. Among these are bistable diodes, which act as negative resistances over portions of their voltage-current characteristics; layer triodes, which can be "fixed" by a signal on one element ("fixed" in a sense similar to that of "fixing" a gas thyratron), and "Zener" diodes, which are proving themselves effective voltage reference devices somewhat like the voltage reference gas tube.

While these devices do not possess the broad versatility of the transistor, their role will be significant in large volume applications. Still other devices, with even more diverse uses, are appearing as a result of intensive semiconductor investigations.

Sensing elements, or energy transducers, also will be important future semiconductor devices. They include infrared detectors, temperature measuring devices (such as thermistors), and nuclear radiation detectors.

Newly developed high sensitivity infrared detectors have helped to spark the recent revival of infrared systems for aircraft and missiles. The future will see infrared systems assume an important military role — not as a replacement for radar but as a complementary component to assure a greater overall effectiveness. Industrial and commercial applications of infrared detectors will follow as a natural consequence of increased availability.

Sun-power cells

Silicon solar cells represent one of the most important byproducts of the intensive semiconductor material studies of the past decade. They convert sunlight to electrical power with an efficiency of 8 to 10%, and already have found application in rural telephone systems and have gone into satellites as transmitter power supplies. In the consumer market, solar cells have found limited application as power sources for transistorized portable radios and hearing aids.

It is safe to predict, however, that increased efficiency and considerably decreased cost for solar cells will be achieved in the future, thus greatly extending the market for such devices. Obviously, the use of solar cells in satellites and space vehicles will be extended for the simple reason that the sun is an unfailing source of energy in space and the silicon solar cell has potentially unlimited usefulness: there is nothing to wear out.

It is equally easy to foresee widespread application of solar cells in backward and impoverished areas of the world that lack other natural energy resources.

In the nuclear field, recent research has led to semiconductor devices capable of measuring and integrating total exposure to neutron radiation. These devices are simple in design and can be "read" promptly. They may be worn like the conventional film badge, thus affording a convenient monitoring of exposure to such radiation.

When all of their past deeds and latent possibilities are considered, semiconductors certainly seem ideally suited to the technology of our times. The future of the semiconductor industry seems assured for many years to come — or at least until another, equally marvelous technological breakthrough occurs. ■

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forecast

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CROSS-DYEING *textiles is possible by mixing fiber types in same fabric.*

These are chemicals in which a metal, or "inorganic" atom such as tin, iron, or silicon, is bonded to the carbon atom of an organic compound.

Tetraethyl-lead, an anti-knock additive in gasoline, is one organometallic manufactured in large volume. Ethyl Corp.'s new AK-33X, an organomanganese compound, reported to be more effective than tetraethyl-lead, has stimulated research on other organo-metallics for this use.

Organoboron compounds will be investigated as high-energy fuels; organotin compounds are being evaluated as mildewproofing agents and in other uses.

The Air Force's Wright Air Development Center is sponsoring an extensive research program on organometallic polymers, with the aim of developing elastomers and plastics to withstand temperatures about 500°F.

Polymers containing tin, silicon, and boron will be studied more and more in 1959.

Cancer and 'emotion drugs'

The success of tranquilizers has spurred research by pharmaceutical companies—Merck, Pfizer, Schering, Warner-Chilcott, among others—on additional drugs that control personality and emotions.

Other active areas of pharmaceutical research are in cancer chemotherapy and in the control of cardiovascular disease. Cardiovascular research is being aided by the National Institutes of Health's $32 million research program. NIH will spend $46 million for research on anticancer drugs (steroids, antimetabolites, byproducts from antibiotic fermentation).

Although cancer researchers have uncovered a dozen chemicals that show some anticancer action, they are pessimistic about achieving any general cures. They are beginning to think that "cancer" may be a broad term covering several related diseases, each of which may require a different type of chemotherapy.

And they adopt a cautious "wait-and-see" attitude about research reports that link cancer with viruses.

The vanishing time-lag

Research that was done in the late 1940s, when the U. S. research effort began to accelerate rapidly, only now is being reflected in the appearance of new products on the market—the lag between invention and marketing being as long as 10 years. Economists expect that the tremendous upsurge in R & D since 1950 will be matched by a flood of new products on the market during the next few years.

Further, cross-fertilization produced by increased research effort should shorten the time needed for development of many new ideas, and thus will multiply fruits of the research cornucopia.

Another aid in reducing the lag between research and production is provided by the newest of the research specialties: market research and operations research. These activities, utilizing newly refined mathematical techniques and high-speed computers, are rapidly furnishing a scientific basis for planning how to use the products of research.

Research activity itself during 1959 will come more and more under control of planners armed with data that Robert E. Johnson, of Western Electric calls "logistics research"—a combination of operations research, market research, industrial intelligence, econometrics, human engineering, etc.

Research scientists, however unfettered they may be in thinking about their work, generally are conservative in their opinions about logistics research. They point out that it may stifle creativity at the same time it directs their activities toward the most fruitful paths of research.

But logistics research, or something like it, is a must for increasing efficiency of the nation's tremendous R & D effort. Twelve billion dollars for research is a fantastic sum. Yet it may be only the beginning. ■

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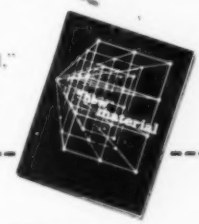

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